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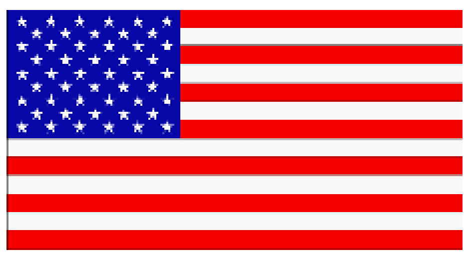


U.S. Missiles

AIM-7 Sparrow

The AIM-7 Sparrow is a radar-guided, air-to-air missile with a high-explosive warhead. The versatile Sparrow has all-weather, all-altitude operational capability and can attack high-performance aircraft and missiles from any direction. The AIM/RIM-7 series is a semiactive, air-to-air, boost-glide missile, designed to be either rail or ejection launched. Semiactive, continuous wave, homing radar, and hydraulically-operated control surfaces direct and stabilize the missile on a proportional navigational course to the target. Propulsion for the missile is provided by a solid propellant rocket motor.

It is a widely deployed missile used by U.S. and NATO (North Atlantic Treaty Organization) forces. In the Persian Gulf war, the radar-guided AIM-7 Sparrow proved to be a potent air-to-air weapon used by Air Force fighter pilots. Twenty-two Iraqi fixed-wing aircraft and three Iraqi helicopters were downed by radar-guided AIM-7 Sparrow missiles. The Sparrow is limitated by the requirement that the aircraft it is fired from must continue to paint the target with radar, limiting that aircraft to straight and level flight.

The AIM-7M/P Sparrow Missile is employed during air-to-air combat missions by Navy F-14, Navy and Marine Corps F/A-18, and Air Force F-15 and F-16 aircraft. The AIM-7 (series) is used primarily to neutralize the threat of high performance enemy aircraft. It is a supersonic, medium-range missile with Defensive Counter Countermeasure capabilities, which includes Electronic Protection from Electronic Attack. It guides on radio frequency energy, processing radar signals received via its rear signal receiver from the launch platform's radar system and reflected target energy received directly from the target. The AIM-7M/P is controlled in flight by four movable delta platform wings. Missile stability is provided by four fixed delta fins which are located in-line with the forward wings. Missile propulsion is provided by a dual-thrust, solid propellant rocket motor. An active radio frequency fuze detonates the warhead when the missile is within lethal range of the target.

The missile has five major sections: radome, radar guidance system, warhead, flight control (autopilot plus hydraulic control system), and solid-propellant rocket motor. It has a cylindrical body with four wings at mid-body and four tail fins. Although external dimensions of the Sparrow remained relatively unchanged from model to model, the internal components of newer missiles represent major improvements with vastly increased capabilities. Sparrow is a supersonic, medium range, aerial-intercept missile, which guides on RF energy. The missile processes radar signals received directly from the launch platform's radar via its rear signal receiver, and also processes RF energy reflected from the target received by its own internal radar receiver (front signal). Sparrow is controlled in flight by four movable delta platform wings. Missile stability is provided by four fixed delta fins which are located in line with the forward wings. Missile propulsion is provided by a dual-thrust, solid propellant rocket motor. An active RF fuze detonates the warhead when the missile is within lethal range of the target. To increase performance in either application, air-to-air or surface-to-air, Sparrow contains

switching circuits that automatically program missile operation for optimum performance in the appropriate environment. The Sparrow Weapon System consists of the radar-guided missile; the support equipment consisting of test, handling, and training equipment, tools and reusable containers; and the aircraft or ship's equipment required to launch the missile.

- **Guidance and Control Section.** The GCS tracks a target, directs and stabilizes the missile on a lead-angle navigation course to the target, and starts warhead detonation by use of an active radar proximity fuze or a backup contact fuze. The guidance system uses energy reflected from the target and data received from the missile fire control system to track the target. A comparison of these signals allows the guidance section to sense changes in target position and create signals used by the control section to control movement of the wings and thus maintain course to target intercept. Missile-to-target closing speed is derived by a comparison of the signals (doppler shift) received by the front antenna and the rear reference antenna.

Guidance Section. The Guidance Section is a solid-state design. The Guidance Section is constructed modularly and includes a radome, tunnel cable to the control section, forward antenna, target and rear receivers, an embedded Missile Borne Computer (MBC), a radar fuze unit, and electric gimbaled motors.

Control Section. The control section consists of an autopilot and a hydraulic control group which provide wing control to guide the missile to the target and to stabilize the missile. An accumulator supplies the hydraulic power to move the wings in response to guidance command signals from the autopilot. In addition to circuits for processing guidance and stabilization signals, the control section also contains an AC/DC converter for adapting external power for missile requirements before launch.

- **Warhead Assembly.** The Warhead Assembly includes a fuze booster, transfer lead (WAU-17 warhead only), Safe-Arm Device (SAD), and the main explosive charge. The warhead assembly is located between the guidance section and control section. It is connected electrically to the guidance section by a SAD cable. At launch, a thrust-activated mechanism in the SAD starts the arming cycle. When the missile receives a launch signal, voltage is applied to unlock the arming mechanism. As the missile accelerates, the arming rotor turns, aligning the explosive train and removing the shorting circuit. This completes the firing circuit. Detonation is triggered by a fuze pulse from the active RF fuzing circuit in the guidance section at the nearest point of intercept or by an impact switch located in the control section.

WAU-10/B and WAU-10A/B Warhead Assembly. The WAU-10/B Warhead Assembly includes a MK-71 Mod 0 Warhead Section with a MK-33 Mod 0 SAD and MK-33 Mod 1 fuze booster. The WAU-10A/B Warhead Assembly is similar to the WAU-10/B except it has a MK-38 Mod 2 fuze booster. Both warhead assemblies are of the insulated continuous-rod type.

WAU-17B and WAU-17A/B Warhead Assembly. The WAU-17B Warhead Assembly includes a WDU-27B Warhead Section with a MK-33 Mod 0 SAD, a MK-38 Mod 1 fuze booster, and a MK-26 Mod 0 transfer lead. The WAU-17A/B Warhead Assembly is similar to the WAU-17B except it has a MK-38 Mod 2 fuze booster. The transfer lead extends the explosive train from the SAD to the fuze booster. Both warhead assemblies are of the end-initiated blast fragmentation type.

- **Fuze Booster.** When ignited by a SAD, the fuze booster charge ignites the main warhead charge. The MK-38 Mod 2 fuze booster is designed to melt rather than detonate when exposed to high heat. This provides an added safety feature for ordnance personnel and fire fighters.
- **Rocket Motor Assembly.** The MK-58 Rocket Motors are dual-thrust, solid propellant propulsion units. The case bonded grain consists of separate boost and sustain propellants in a side-by-side configuration. The rocket motor assembly consists of three major subassemblies: a case with propellant grain, a safe-arm ignition assembly and a nozzle weather seal at the rear. Integral parts of the case are the attachment points which include the forward skirt, launch hooks, waveguide clips, antenna bracket, and fin dovetail slots.

MK-58 Mods 2, 3, and 5 Rocket Motor Assemblies. These rocket motor assemblies are used with the air-launched missiles (AIM-7M/P) and include a safe-arm ignition assembly with an Arm-Fire Device (AFD) relock assembly. The AFD relock T-handle, which locks in either the SAFE or ARM position, cannot be removed, and is used to arm the rocket motor manually before flight.

- **Wing and Fin Assemblies.** Four wings and four fins provide the flight control surfaces for Sparrow. The wings attach to the hub assembly of the control section and the fins mount into dovetail quick-attach fittings on the rear of the rocket motor.
- **Rear Waveguide Assembly.** A structural rear waveguide assembly containing the rear antenna is installed externally on the missile airframe. The rear waveguide is constructed in two parts with the forward section connecting to internal RF circuitry in the guidance section. The forward section also serves as a protective cover for the tunnel cable which electrically interconnects the GCS. The aft assembly contains the rear antenna and is joined to the forward section at the rear of the control section, and runs aft to the rear of the rocket motor.

Training Missiles. The AIM-7 Missile System uses several types of training missiles: Air-launched Training Missile (ATM)-7M/P; the Captive Air Training Missile (CATM)-7F- 3; and the Dummy Air Training Missile (DATM)-7F-11. The ATM-7M/P is a live-fire missile that is an AIM-7M/P with the warhead section replaced with a telemetry section. The CATM-7F-3 and the DATM-7F-11 are used primarily for AIM-7M/P maintenance training, and are completely inert. Additionally, the CATM-7F-3 is used by F-14 aircrews for some training events/exercises. F/A-18 aircrews use a simulator plug (commonly referred to as a wafer) in the launcher umbilical that precludes the use of the CATM-7F-3, and enables the aircraft's embedded training capability via its on-board computers.

Variants

The Sparrow missile is a supersonic, medium-range, aerial-intercept missile that guides on Radio Frequency (RF) energy. Sparrow incorporates Electronic Counter-Countermeasure (ECCM) capabilities, also known as Electronic Protection (EP), to defeat countermeasures such as jamming. The Sparrow began as project Hotshot in 1946, and became operational in late 1953. Experience during the Vietnam war demonstrated it to be virtually useless against manuvering targets. A special AIM-7E-2 dogfight version was produced to overcome these shortcomings. Current configurations of the Sparrow

missile include four air-launched variants, AIM-7M F1 Build, AIM-7M H Build, AIM-7P Block I, and AIM-7P Block II, and as many ship-launched variants, RIM-7M F1 Build, RIM-7M H Build, RIM-7P Block I, and RIM-7P Block II.

Each new version has resulted in substantial improvement in missile performance. The AIM/RIM-7E reduced minimum range restrictions and provided dogfight capabilities. The RIM-7H incorporates rapid run-up capabilities, providing improvements over previous versions. The AIM-7F incorporates solid state circuitry and modular design, an improved warhead, and a boost-sustain rocket motor. The AIM/RIM-7R is most recent configuration and adds a dual mode radio frequency/infrared (RF/IR) seeker capability.

- The **AIM-7F** joined the Air Force inventory in 1976 as the primary medium-range, air-to-air missile for the F-15 Eagle. The AIM-7F was an almost completely new missile, gaining ability from improved avionics that allowed the warhead to be moved to the front, allowing a bigger motor to be carried that has improved range.

- The **AIM-7M**, the only current operational version, entered service in 1982. It has improved reliability and performance over earlier models at low altitudes and in electronic countermeasures environments. It also has a significantly more lethal warhead. The latest software version of the AIM-7M is the H-Build, which has been produced since 1987 and incorporates additional improvements in guidance. AIM/RIM-7M DT and OT was successfully completed in FY82. The F-15 Eagle and F-16 Fighting Falcon fighters carry the AIM-7M Sparrow.
- The **RIM-7M** Sparrow is employed during ship-to-air combat missions by Spruance class Destroyers outfitted with the North Atlantic Treaty Organization (NATO) Sea Sparrow Missile System (NSSMS). In ship-to-air combat evolutions, Sparrow is used primarily to neutralize the threat of high performance, anti-ship missiles. The RIM-7M guidance and control section is common with the AIM-7M. When used in the surface launched RIM configuration, folding wings, clipped fins, and a remotely armable rocket motor are used.
- The **AIM/RIM-7P** Sparrow missile has undergone two block modifications. The AIM/RIM-7P Block I provides low altitude guidance and fuzing capability. The AIM/RIM-7P Block II provides increased memory and throughput to the MBC, enhanced production software reprogrammable capability, and mid-course uplink improvements to the rear receiver. The AIM/RIM-7P Block I retrofit included an upgrade of the MBC in the guidance section (WGU-6D/B) and incorporation of a new fuze (DSU-34/B). Approximately 600 missiles were upgraded to the Block I configuration. The AIM/RIM-7P Block II upgrade included modification of the MBC in the Guidance Section (WGU-23D/B), incorporation of the new fuze, and a new rear receiver. The AIM/RIM-7P Block I and AIM/RIM-7P Block II have the same approximate weight, center of gravity, and general mass distribution properties as the AIM/RIM-7M Guidance Sections. The AIM/RIM-7P program began as a retrofit program to AIM/RIM-7M Guidance and Control Sections (GCS) and resulted in a new build contract for AIM/RIM-7P Block II GCS. Follow-on AIM/RIM-7P Block II procurements will upgrade existing AIM-7M inventories and provide replacement for AIM-7M missiles lost through FMS. Remaining AIM-7M Missiles will continue to be supported until phase-out or other action through

the FMS Replacement-In-Kind (RIK) program. The AIM/RIM-7P Sparrow Test and Evaluation Master Plan, M159-1RIM-7P, dated 21 July 1989, was developed for the AIM/RIM-7P. Developmental and operational test and evaluation phases for the AIM/RIM-7P have been completed. Developmental Test (DT) for the AIM/RIM-7P occurred in first quarter FY90 through second quarter FY90. Operational Test (OT) occurred in third quarter FY90 through second quarter FY91. Follow-On Test and Evaluation (FOT&E) for Block I and II AIM/RIM-7P Missiles was completed fourth quarter FY93 through second quarter FY94 using retrofit kits in Government Furnished Equipment missiles. The AIM/RIM-7P was introduced to the fleet through GCS retrofit and GCS new production contracts. The AIM/RIM-7P retrofit program began deliveries in November 1993. Because the upgrade from AIM/RIM-7M to AIM/RIM-7P did not impact Carrier Air Group (CAG) operation and maintenance procedures, a unique Fleet introduction was not required. All AIM/RIM-7P upgraded elements are contained in the guidance section to reduce technical risk. The AIM-7P modifications are incorporated in blocks.

- The **AIM/RIM-7R** was the latest Sparrow new development, but the program was halted in the first quarter of FY97 following completion of its DT/OT program. The AIM/RIM-7R integrated a passive infrared seeker in its radome for terminal guidance. Requirements for a dual mode seeker AIM-7R were rescinded in FY96. The AIM/RIM-7P Block II was the baseline for the AIM/RIM-7R missile.

Specifications

Primary Function	Air-to-air guided missile
Contractor	Raytheon Co.
Power Plant	Hercules MK-58 solid-propellant rocket motor
Thrust	Classified
Speed	Classified
Range	approximately 30 nm
Length	12 feet (3.64 meters)
Diameter	8 inches (0.20 meters)
Wingspan	3 feet, 4 inches (1 meter)
Warhead	Annular blast fragmentation warhead 88 lbs high explosive for AIM-9H
Launch Weight	Approximately 500 pounds (225 kilograms)
Guidance System	Raytheon semiactive on either continuous wave or pulsed Doppler radar energy
Date Deployed	1976
Aircraft Platforms	Navy: F-14 and F/A-18; Air Force: F-4, F-15, and F-16;

	Marine Corps: F-4 and F/A-18
Unit Cost	Approximately $125,000
Inventory	Classified





AIM-9 Sidewinder

The AIM-9 Sidewinder is a supersonic, heat-seeking, air-to-air missile carried by fighter aircraft. It has a high-explosive warhead and an active infrared guidance system. The Sidewinder was developed by the US Navy for fleet air defense and was adapted by the U.S. Air Force for fighter aircraft use. Early versions of the missile were extensively used in the Southeast Asian conflict. In September 1958 Chinese Nationalist F-86s fired the first Sidewinder air-to-air missiles to down 11 communist Chinese MiG-17s over the Formosa Straits. Until that time, aircraft defensive means where primarily limited to pilots and tail gunners firing small caliber ammunition in dog-fight situations.

The AIM-9 has a cylindrical body with a roll-stabilizing rear wing/rolleron assembly. Also, it has detachable, double-delta control surfaces behind the nose that improve the missile's maneuverability. Both rollerons and control surfaces are in a cross-like arrangement.

The missile's main components are an infrared homing guidance section, an active optical target detector, a high-explosive warhead, and a rocket motor.

The infrared guidance head enables the missile to home on target aircraft engine exhaust. An infrared unit costs less than other types of guidance systems, and can be used in day/night and electronic countermeasures conditions. The infrared seeker also permits the pilot to launch the missile, then leave the area or take evasive action while the missile guides itself to the target.

Variants

The development process has produced increased capabilities with each missile modification.

The **AIM-9A**, prototype of the Sidewinder, was first fired successfully in September 1953. The initial production version, designated AIM-9B, entered the Air Force inventory in 1956 and was effective only at close range. It could not engage targets close to the ground, nor did it have nighttime or head-on attack capability. These shortcomings were eliminated on subsequent versions.

The **AIM-9G** provided the capability to lock on and launch against a target offset from the axis of the launch aircraft.

The **AIM-9H** configuration replace vacuum tubes with solid-state modules and a thermal battery replaced the turbo-alternator. The AIM-9H was configured with a continuous-rod bundle warhead.

The **AIM-9J**, a conversion of the AIM-B and E models, has maneuvering capability for dogfighting, and greater speed and range, giving it greater enhanced aerial combat capability. Deliveries began in 1977 to equip the F-15 and other Sidewinder-compatible aircraft.

The **AIM-9L** added a more powerful solid-propellant rocket motor as well as tracking maneuvering ability. Improvements in heat sensor and control systems have provided the AIM-9L missile with an all-aspect attack capability and improved guidance characteristics. The L model was the first Sidewinder with the ability to attack from all angles, including head-on. An improved active optical fuze increased the missile's lethality and resistance to electronic countermeasures. A conical scan seeker increased seeker sensitivity and improved tracking stability. The AIM-9L is configured with an annular blast fragmentation warhead. Production and delivery of the AIM-9L began in 1976.

The **AIM-9M** missile utilizes a guidance control section with counter-countermeasures and improved maintainability and producibility. The AIM-9M is configured with an annular blast fragmentation warhead.

The **AIM-9P**, an improved version of the J model, has greater engagement boundaries, enabling it to be launched farther from the target. The more maneuverable P model also incorporated improved solid-state electronics that increased reliability and maintainability. Deliveries began in 1978.

The **AIM-9P-1** has an active optical target detector instead of the infrared influence fuze; the AIM-9P-2 added a reduced-smoke motor. The most recently developed version, the AIM-9P-3, combined both the active optical target detector and the reduced-smoke motor. It also has added mechanical strengthening to the warhead as well as the guidance and control section. The improved warhead uses new explosive material that is less sensitive to high temperature and has a longer shelf life.

The **AIM-9M**, currently the only operational variant, has the all-aspect capability of the L model, but provides all-around higher performance. The M model has improved defense against infrared countermeasures, enhanced background discrimination capability, and a reduced-smoke rocket motor. These modifications increase ability to locate and lock-on a target and decrease the missile's chances for detection. Deliveries of the M model began in 1983.

The **AIM-9M-9** has expanded infrared counter measures detection circuitry.

The **AIM-9X** Sidewinder Air-to-Air missile program will develop a short range heat seeking weapon to be employed in both offensive and defensive counter-air operations.

Offensively, the weapon will assure that US and combined air forces have the ability project the necessary power to insure dominant maneuver. In the defensive counter-air role, the missile system will provide a key capability for force protection. The multi-service Air Intercept Missile (AIM-9X Sidewinder) development will field a high off-boresight capable short range heat seeking missile to be employed on US Air Force and Navy/Marine Corps fighters. The missile will be used both for offensive and defensive counter-air operations as a short range, launch and leave air combat missile that uses infra red guidance. The AIM-9X will complement longer range radar guided missiles such as the Advanced Medium Range Air-to-Air Missile (AMRAAM).

The new missile is required to reestablish the parity of US aircraft in short range air combat, vis-à-vis improved foreign export aircraft and missiles. Specific deficiencies exist in the current AIM-9M in high off-boresight angle capability, infra-red counter-countermeasures robustness, kinematic performance, and missile maneuverability. The MiG-29 with its AA-10/AA-11 missiles are the major threat to US forces. Additionally, there are a number of other missiles on the world market that outperform the current US inventory AIM-9M weapon system in the critical operational employment areas.

The AIM-9X will expand the capabilities of the current AIM-9M by developing a new seeker imaging infra-red focal plane array, a high performance airframe, and a new signal processor for the seeker/sensor. The current acquisition strategy seeks to retain the warhead, fuze, and rocket motor of the current design in order to capitalize on the large existing inventory of AIM-9 weapons. The F-15C/D and the F/A-18C/D will be the initial platforms for integration and T&E.

The early operational assessment of the Hughes and Raytheon DEMVAL results was that both the Hughes and Raytheon missiles showed potential for meeting both the mission effectiveness and suitability requirements of the AIM-9X operational requirements document. Specifically, all critical operational issues were rated green (potentially effective/suitable) except counter-countermeasures capability, lethality, built in test functionality, and reprogrammability. Counter-countermeasures capability of both missiles was initially below the operationally required threshold values, however the Hughes missile showed a rapid improvement through the course of the evaluation. The missiles demonstrated acceptable performance levels in the air-to-air phase. The other assessment areas not resolved as green had insufficient data for conclusive evaluation. However, again, the risk of either DEMVAL missile not meeting the threshold requirement was rated as low. The results of the operational assessment were integral to the Service source selection decision to award the engineering, manufacturing, development contract to Hughes Missile Systems Corporation.

The early operational assessment of the British ASRAAM foreign comparative test (FCT) focused on the risk areas of the ASRAAM: focal plane array effectiveness, seeker signal processing, warhead effectiveness, rocket motor testing, and kinematic/guidance ability to support the lethality requirements of the AIM-9X. The resulting assessment was that the ASRAAM (as is) cannot meet the AIM-9X operational requirements in high off-boresight angle performance, infrared counter-countermeasures robustness, lethality, and interoperability.

The AIM-9X is a supersonic, air-to-air, guided missile which employs a passive IR target acquisition system, proportional navigational guidance, a closed-loop position servo Control Actuation Section (CAS), and an AOTD. The AIM-9X is launched from an aircraft after target detection to home in on IR emissions and to intercept and destroy enemy aircraft. The missile interfaces with the aircraft through the missile launcher using a forward umbilical cable, a mid-body umbilical connector and three missile hangars. The AIM-9X has three basic phases of operation: captive flight, launch, and free flight.
The AIM-9X utilizes the existing AIM-9M AOTD, warhead, and rocket motor, but incorporates a new Guidance Section (GS), new hangars, a new mid-body connector, new harness and harness cover, new titanium wings and fins, and a new CAS. The missile is propelled by the AIM-9M solid-propellant rocket motor, but uses a new Arm and Fire Device (AFD) handle design. Also, the AIM-9M rocket motor is modified to mount the CAS on its aft end. Aerodynamic lift and stability for the missile are provided by four forward-mounted , fixed titanium wings. Airframe maneuvering is accomplished by four titanium control fins mounted in line with the fixed wings and activated by the CAS, which includes a thrust vector control system that uses four jet vanes to direct the flow of the rocket motor exhaust. The AIM-9X is configured with the AIM-9M Annular Blast Fragmentation (ABF) warhead, which incorporates a new Electronic Safe and Arm Device (ESAD) to arm the warhead after launch. The AIM-9M AOTD is used to detect the presence of a target at distances out to the maximum effective range of the missile warhead and command detonation.

- **Guidance Section.** The GS provides the missile tracking, guidance, and control signals. It consists of three major subassemblies: (1) a mid-wave IR Focal Plane Array (FPA) seeker assembly for detecting the target, (2) an electronics unit that converts the detected target information to tracking and guidance command signals, and (3) a center section containing the cryoengine, contact fuze device, two thermal batteries, and required harnesses and connectors. The coolant supply for the GS is provided by the twin-opposed-piston, linear drive, Stirling cryoengine.
- **Forward Hangar/Mid-body Umbilical Connector and Buffer Connector.** The hangers on the AIM-9M rocket motor are replaced by slightly "taller" hangers for AIM-9X. These taller hangers provide additional separation between the missile and the launcher. This separation is needed to provide adequate clearance for the AIM-9X on all the launcher configurations. The middle and aft hanger mounting is unchanged from the AIM-9M configuration. The forward hanger is replaced by an integrated forward hanger/mid-body umbilical assembly. The mid-body umbilical connector adds a mid-body interface with the LAU-127 launcher. This connection provides the missile MIL-STD-1553 digital communications with the launching aircraft, and requires a buffer connector similar to the Advanced Medium-Range Air-to-Air Missile (AMRAAM)

buffer connector. The forward hanger/mid-body umbilical assembly is an integrated assembly that consists of the hanger, the mid-body umbilical connector, the umbilical cabling, and the rocket motor AFD wiring to the hanger striker points. The rocket motor AFD wiring is unchanged from that used in the AIM-9M and will interface with the striker points as in the AIM-9M configuration.

- **Harness and Harness Cover.** Unlike the AIM-9M, an electronic harness has been added to the AIM-9X to provide the communications interface between the electronics unit in the GS and the other missile components. Due to the lack of space internally, the harness had to be mounted externally on the underside of the missile surface. The harness cover spans most of the length of the missile and provides an aerodynamic surface and protective cover for the electronic harness and the CAS electronic circuit board.

The AIM-9X will utilize mid-wave IR FPA seeker technology in lieu of the single-element IR seeker used in the AIM-9M. The AIM-9X will be a digital missile with Built-In-Test (BIT) and re-programming capability that is not present in the the analog AIM-9M. A buffer connector must be used on the mid-body umbilical connector when the AIM-9X is loaded on the LAU-127 launcher. The AIM-9X will use an internal cryogenic engine, called a cryoengine, for IR element cooling. The cryoengine does not require externally-supplied coolant, e.g., nitrogen, and thus does not use the nitrogen receiver assemblies contained in the LAU-7 and LAU-127 launchers, which provide IR element coolant for the AIM-9M. The AIM-9X will use titanium wings and fins. Also, the AIM-9X will use a CAS to direct movement of the aft fins and four internal jet vanes. The jet vanes direct the flow of the rocket motor exhaust to generate thrust vector control.

Fleet introduction of the AIM-9X missile is planned to begin in FY02 via aircraft carrier load outs. Low-Rate Initial Production (LRIP) All-Up-Round (AUR) missile deliveries begin in FY01 and continue through FY04, when Full-Rate Production deliveries begin.

The AIM-9X seeks and homes in on IR energy emitted by the target. When an IR-emitting source enters the seeker field of view, an audio signal is generated by the electronics unit. The pilot hears the signal through the headset, indicating that the AIM-9X has acquired a potential target. One method of cueing the AIM-9X to the target's IR energy source is referred to as boresight, whereby the missile is physically pointed toward the target via the pilot maneuvering the aircraft. The IR energy gathered by the missile seeker is converted to electronic signals that enable the missile to acquire and track the target up to its seeker gimbal limits. A second method of cueing the AIM-9X to the target's IR energy is the Sidewinder Expanded Acquisition Mode (SEAM). SEAM slaves the AIM-9X seeker to the aircraft radar. The aircraft avionics system can slave the missile seeker up to a given number of degrees from the missile/aircraft boresight axis. The missile seeker is slaved until an audible signal indicates seeker target acquisition. Upon target acquisition, a seeker interlock in the missile is released (uncaged) and the missile seeker begins tracking the target. The AIM-9X seeker will then continue to track the target. A third method for cueing the AIM-9X to the target's IR energy is through use of the JHMCS. This method allows the pilot to cue the AIM-9X seeker to high off-boresight targets via helmet movement. The pilot can launch the AIM-9X anytime after receipt of the appropriate audible signal.

The AIM-9X is required to be compatible, at full capability, with the F/A-18C/ D/E/F, F-15C/D/E, F-16C/D, and F-22 aircraft, and be capable of being used in a reduced capacity on other aircraft with MIL-STD-1760 signal set capability (F-14B Upgrade, F-14D, AV-

8B, and AH-1W). The AIM-9X is also backward compatible to aircraft/launchers only capable of AIM-9M analog communication. For analog interfaces, the AIM-9X operates, and is identified, as an AIM-9M. This backward compatibility includes the analog seeker slave mode. The AIM-9X will be integrated with the Joint Helmet Mounted Cueing System (JHMCS), a helmet-mounted display with capability to cue and verify cueing of high off-boresight sensors and weapons. This missile-helmet marriage will provide the aircrew with first-look, first-shot capability in the air-to-air, within visual range, combat arena. Increased off-boresight acquisition angle and improved situational awareness will be achieved through the integrated combination of the AIM-9X missile, the JHMCS and the aircraft.

For the USN and United States Marine Corps (USMC), two guided missile launchers are available to carry and launch the AIM-9X on the F/A-18 aircraft. The LAU-7 guided missile launcher can be used on all applicable Sidewinder weapons stations, however, it requires modification of the current power supply and the addition of digital and addressing lines to the forward umbilical to carry and launch the AIM-9X. With these modifications, it will be designated the LAU-7D/A. The LAU-127 guided missile launcher can be used on the F/A-18 aircraft wing stations only. F/A-18 aircraft wing stations require a LAU-115 guided missile launcher in order to attach the LAU-127.

Specifications

Primary Function	Air-to-air missile
Contractor	Naval Weapons Center
Power Plant	Hercules and Bermite Mk 36 Mod 71, 8 solid-propellant rocket motor
Thrust	Classified
Speed	Supersonic Mach 2.5
Range	10 to 18 miles depending on altitude
Length	9 feet, 5 inches (2.87 meters)
Diameter	5 inches (0.13 meters)
Finspan	2 feet, 3/4 inches (0.63 meters)
Warhead	Annular blast fragmentation warhead 25 lbs high explosive for AIM-9H 20.8 lbs high explosive for AIM-9L/M
Launch Weight	190 pounds (85.5 kilograms)
Guidance System	Solid-state, infrared homing system
Introduction Date	1956
Unit Cost	Approximately $84,000
Inventory	Classified





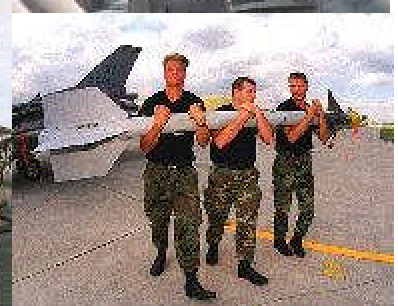





VFA-86
Sidewinders











AIM-54 Phoenix Missile

The AIM-54 Phoenix Long-range air-to-air missile, carried in clusters of up to six missiles on the F-14 Tomcat. The Phoenix missile is the Navy's only long-range air-to-air missile. It is an airborne weapons control system with multiple-target handling capabilities, used to kill multiple air targets with conventional warheads. The weapon system consists of an AIM-54 guided missile, interface system, and a launch aircraft with an AN/AWG-9 weapon control system. The AIM-54 is a radar-guided, air-to-air, long-range missile consisting of a guidance, armament, propulsion, and control section, interconnecting cables, wings and fins. The total weapon system has the capability to launch as many as six AIM-54 missiles simultaneously from the F-14 aircraft against an equal number of targets in all weather and heavy jamming environments.

The AIM-54 Phoenix Missile was developed in the 1970s as the principle long-range, air-to-air, defense armament of the F-14 Aircraft. The AIM-54 Phoenix Missile is a fielded weapon currently in Phase III, the Production, Fielding/Deployment, and Operational Support Phase of the Weapon System Acquisition Process.

The three versions of the AIM-54 Phoenix Missile currently being used are the AIM-54A, AIM-54C, and the AIM-54 ECCM/Sealed. The AIM-54 is a radar-guided, air-to-air, long-range missile consisting of a guidance, armament, propulsion, and control section, interconnecting cables, wings and fins. The AIM-54A was the original version to become operational. The improved Phoenix, the AIM-54C, can better counter projected threats from tactical aircraft and cruise missiles. The AIM-54C (sealed) missile is the most recent version and contains improved electronic counter-countermeasure capabilities and does not require coolant conditioning during captive flight. The AIM-54C and AIM-54C (sealed) contains built-in self test and additional missile on-aircraft test capability. The AIM-54C missile has also been designed for greater reliability, longer serviceable in-service time, and a 15 percent reduction in parts.

Initial Operating Capability was attained in 1974 for the AIM-54A, 1986 for the AIM-54C, and 1988 for the AIM-54C ECCM/Sealed. The AIM-54C and AIM-54C ECCM/Sealed are replacing the AIM-54A. As AIM-54A inventories are depleted they will not be replenished. The AIM-54A Technical Evaluation (TECHEVAL) was completed in November 1973. Operational Evaluation (OPEVAL) was completed in November 1974. The AIM-54C TECHEVAL began in May 1982 and was completed in November 1982. The OPEVAL began in March 1983 and was completed in August

1983. AIM-54C ECCM/Sealed Missile TECHEVAL was completed in June 1985, and OPEVAL was completed in July 1988.

The AIM-54 Phoenix Missile, used exclusively on the F-14A/B/D Aircraft, is a radar guided, air-to-air missile consisting of a guidance section, armament section, propulsion section, control section, interconnecting surface cables, wings, and fins. The missile is designed for ejection launch using the LAU-93 or LAU-132 launchers. Semi-active and active homing radar and hydraulically operated fins direct and stabilize the missile on course to the target. Propulsion is provided by a solid propellant rocket motor, and lethality by a high explosive warhead. Performance modifications to the AIM-54A were incorporated during and after production. The Reject Image Device (RID), High Altitude Performance (HAP), and Extended Active Gate (EAG) were incorporated during production. The MK 11 MOD 3 Electronics Assembly (EA) modification was installed by retrofit after production. The AIM-54C and AIM-54C ECCM/Sealed Missile have a Built In Self Test (BIST) feature. BIST may be selected in conjunction with Missile On Aircraft Test (MOAT). The AIM-54C ECCM/Sealed Missile provides two major improvements over the AIM-54C. ECCM provides enhanced electronic protection and sealing the missile eliminates the requirement for aircraft supplied liquid thermal conditioning fluid during captive flight.

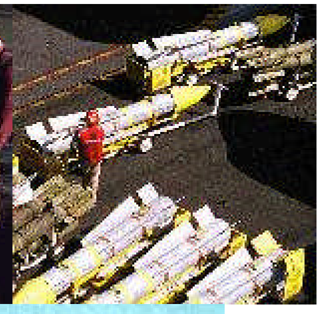
- **Guidance Section** The AIM-54A RID modification offers improved capabilities against low altitude targets over water. The EAG modification improves capabilities against certain Electronic Counter Measure (ECM) threats. The AIM-54C Guidance Section has a new Solid-State Receiver-Transmitter Unit (SSRTU), Digital Electronics Unit (DEU), and Inertial Sensor Assembly (ISA) as well as a modified guidance section wiring harness. Design improvements reduce inherent oscillator drift, provide range discrimination, and improve reliability. In the AIM-54 ECCM/Sealed Missile the DEU front receiver has been modified and an improved version of the program memory has been added to enhance ECCM capabilities. Heaters have been added, operating temperatures of selected subassemblies have been extended, and circuit temperature compensation has been added for sealed operation. The SSRTU has been modified to improve ECCM performance, selected subassemblies have been improved to increase operating temperature ranges, circuit temperature compensation has been added for sealed operation, and the ISA has been modified to include a heater for sealed operation.
- **Armament Section** The AIM-54A's MK 11 MOD 3 EA modification upgrades the Targeting Detecting Device (TDD) to improve warhead lethality against short targets. The AIM-54C has a new TDD, the DSU-28, utilizing the MK 82 MOD 0 warhead. The MK 82 MOD 0 warhead is used with the DSU-28 on AIM-54C All-Up-Round (AUR), serial number 83001 through 83054. A new warhead, WDU-29/B was incorporated in the FY83 production of the AIM-54C AUR starting with serial number 83055. The new warhead offers a 20-25 percent increase in effectiveness. The AIM-54C ECCM/Sealed Missile uses the same armament section as the AIM-54C.
- **Propulsion Section.** The AIM-54A, AIM-54C, and AIM-54C ECCM/Sealed Missile use the MK 47 MOD 1 rocket motor assembly.
- **Control Section** The AIM-54A's HAP modification improves capabilities against very high and fast targets. The AIM-54C Electronic Servo Control Amplifier (ESCA) replaces the autopilot unit in the AIM-54A control section. In the AIM-54 ECCM/Sealed Missile

the Electrical Conversion Unit (ECU) has been completely redesigned for sealed operations. The new design requires no heater for temperature regulation.

The AIM-54 Phoenix Missile maintenance concept is based on an overall objective to assure All-Up-Rounds are available to fulfill commitments of operational activities and provide the means to restore unserviceable missiles to serviceable condition with minimal downtime. Maintenance requirements are allocated to the organizational, intermediate, and depot levels of maintenance.

Specifications

Primary Function	Long-range air-launched air intercept missile
Contractor	Hughes Aircraft Co. and Raytheon Co.
Unit Cost	$477,131
Power Plant	Solid propellant rocket motor built by Hercules
Length	13 feet (3.9 meters)
Weight	1000 pounds - AIM-54A 1040 pounds - AIM-54C [various, 1020-1040 pounds] 1023 pounds - AIM-54C ECCM/Sealed Missile
Diameter	15 inches (38.1 cm)
Wing Span	3 feet (.9 meters)
Range	In excess of 100 nautical miles (115 statute miles, 184 km)
Speed	In excess of 3,000 mph (4,800 kmph)
Guidance System	Semi-active and active radar homing
Warheads	Proximity fuse, high explosive
Warhead Weight	135 pounds (60.75 kg)
Date Deployed	1974


AIM-120 AMRAAM Slammer

The AIM-120 advanced medium-range air-to-air missile (AMRAAM) is a new generation air-to-air missile. It has an all-weather, beyond-visual-range capability and is scheduled to be operational beyond 2000. AMRAAM is a supersonic, air launched, aerial intercept, guided missile employing active radar target tracking, proportional navigation guidance, and active Radio Frequency (RF) target detection. It employs active, semi-active, and inertial navigational methods of guidance to provide an autonomous launch and leave capability against single and multiple targets in all environments.

The AMRAAM weighs 340 pounds and uses an advanced solid-fuel rocket motor to achieve a speed of Mach 4 and a range in excess of 30 miles. In long-range engagements AMRAAM heads for the target using inertial guidance and receives updated target information via data link from the launch aircraft. It transitions to a self-guiding terminal mode when the target is within range of its own monopulse radar set. The AIM-120 also has a "home-on-jam" guidance mode to counter electronic jamming. With its sophisticated avionics, high closing speed, and excellent end-game maneuverability, chances of escape from AMRAAM are minimal. Upon intercept an active-radar proximity fuze detonates the 40-pound high-explosive warhead to destroy the target. At closer ranges AMRAAM guides itself all the way using its own radar, freeing the launch aircraft to engage other targets.

The AMRAAM is being procured for the Air Force, US Navy and America's allies. The AMRAAM program improves the aerial combat capabilities of U.S. and allied aircraft to meet current and future threat of enemy air-to-air weapons. AMRAAM is compatible with the Air Force F-15, F-16 and developmental F-22; Navy F-14 D/D (R) and F/A-18 C/D; German F-4 and the British Sea Harrier aircraft. A small number of AMRAAMs were carried by F-15 aircraft during Operation Desert Storm, though none were used. The AIM-120 was redeployed to the Persian Gulf in 1992 for use on F-15 and F-16 fighters. In December 1992 an F-16 pilot fired the first AMRAAM in actual combat, shooting down a MiG-25 Foxbat during a confrontation over southern Iraq.

AMRAAM is a follow-on to the AIM-7 Sparrow missile series. The missile is faster, smaller and lighter, and has improved capabilities against low-altitude targets. It incorporates an active radar with an inertial reference unit and micro-computer system, which makes the missile less dependent upon the fire-control system of the aircraft. Once the missile closes on a target, its active radar guides it to intercept. This enables the pilot to aim and fire several missiles simultaneously at multiple targets. The pilot may then perform evasive maneuvers while the missiles guide themselves to their targets.

The AIM-120 grew out of a joint agreement, no longer in effect, among the United States and several NATO nations to develop air-to-air missiles and to share the production technology. The AMRAAM program was established as a result of Joint Service Operational Requirement for an Advanced Air-to-Air Tactical Missile needed in the post-

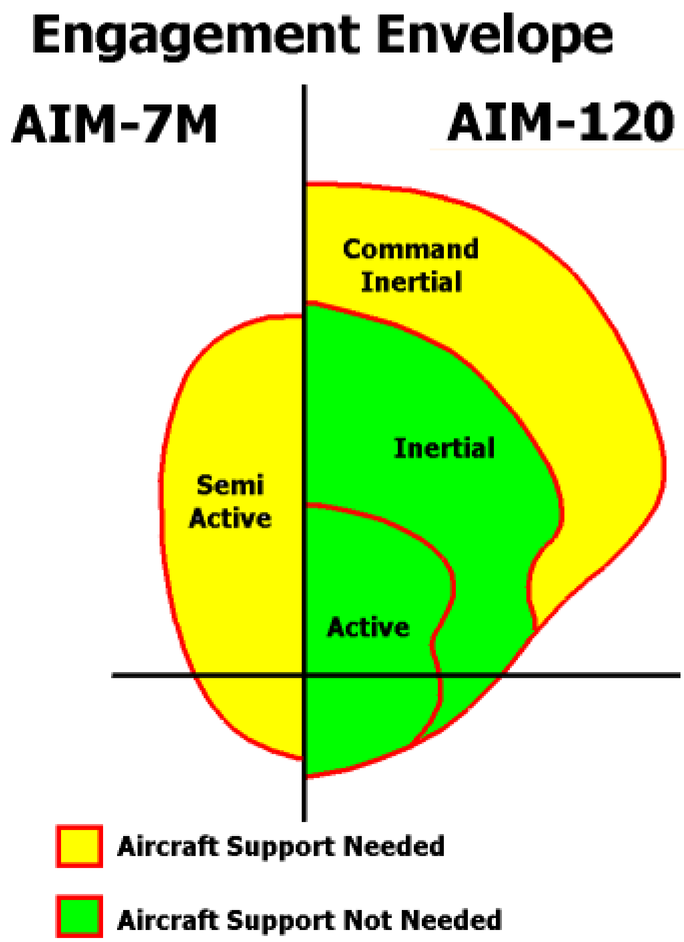
1985 time frame. The AMRAAM program began with a 1975 study which recommended that future aerial threats be engaged at 3-40 miles of range.

The AMRAAM program completed its conceptual phase in February 1979 when the U.S. Air Force selected two of five competing contractors, Hughes Aircraft Co. and Raytheon Co., to continue into the validation phase. During the 33-month validation phase the contractors continued missile development by building actual hardware to demonstrate their technological concepts. The program phase concluded in December 1981 after both contractors demonstrated that their flight-test missiles could satisfy Air Force and Navy requirements. The Air Force competitively selected Hughes Aircraft Co.'s Missile System Group, Canoga Park, Calif., as the full-scale developer.

AMRAAM is managed as a joint Air Force and Navy program. The Air Force, as executive service, established a Joint System Program Office (JSPO) at Air Force Material Command/Aeronautical Systems Center, Eglin Air Force Base, Fort Walton Beach, Florida. The JSPO is headed by the Air Force Deputy for AMRAAM (Code ASC/YA) and the Navy AMRAAM Program Manager, Air (PMA268). AMRAAM is currently in the Production, Fielding/Deployment and Operational Support Phase of the Weapon System Acquisition Process. Air Force Initial Operating Capability (IOC) was declared in September 1991. Navy IOC was completed in September 1993.

During the full-scale development phase, Hughes Aircraft Co. completed missile development and Raytheon was selected as a follower producer. A production contract to both vendors was awarded in 1987. More than 200 of the test missiles were launched during flight tests at Eglin AFB, Fla.; White Sands Missile Range, N.M.; and Point Mugu, Calif. Testing was accomplished in a combined Developmental Test and Evaluation and Initial Operational Test and Evaluation program. Successful Navy operational testing on the F/A-18C/D aircraft was conducted by Commander Operational Test and Evaluation Force during FY94 and included an evaluation of the missile system’s effectiveness and suitability, maintainability, and supportability in the Navy operational environment.

The missile is operational on U.S. Air Force F-15 and F-16 aircraft. The Navy began receiving AIM-120A deliveries in 1991, but delayed Fleet introduction until integration with the F/A-18 aircraft was completed in 1993. Fleet introduction coincided with F/A-18 IOC when CV/CVN load-outs began to include AIM-120A. AMRAAM is combat tested, scoring two kills during Operation Southern Watch, and one kill in Bosnia.



In April 1998 Air Force officials announced the twelfth award to Raytheon Systems Company for the production of 813 additional Advanced Medium Range Air-to-Air Missiles. The total contract value is $243 million. The Lot 12 purchase includes 173 missiles for the Air Force, 120 for the Navy and an additional 520 for foreign customers. Historically, AMRAAM production awards were accomplished under a competitive, dual-source strategy with Hughes Missile Systems Company, Tucson, Ariz., and Raytheon Electronic Systems, Bedford, Mass., as the prime contractors. When Raytheon and Hughes Missile Company merged, forming the current Raytheon Systems Company, a single prime contractor, the government implemented a new strategy called AMRAAM Vision 2000. With Vision 2000, the government shifted toward a more commercial business arrangement with the contractor. Capitalizing on the efficiencies of a single prime contractor, the Air Force and the Navy recognized savings in excess of $150 million, resulting from a drop in unit price from $340,000 in Lot 11 to $299,000 in Lot 12.

Variants

Presently, there are three series of AMRAAM: AIM-120A, AIM-120B, and AIM-120C.

- **AIM-120A.** First production AIM-120A, delivered by Hughes in 1988 to the 33d TFW at Eglin AFB, Florida.
- **AIM-120B** and **AIM-120C** versions are currently in production, the latter with smaller control surfaces to permit increased internal carriage capability in the F-22. AIM-120B deliveries began in FY 94, and AIM-120C deliveries began in FY 96.
- **P3I.** An improvement program seeks to develop AMRAAM capabilities, including software reprogrammability, advanced counter-countermeasures, and options for improved propulsion.

The AIM-120A is a non-reprogrammable missile (requires a hardware change to upgrade the missile software). The AIM-120B/C is reprogrammable through the missile umbilical using Common Field-level Memory Reprogramming Equipment (CFMRE). The AIM-120C has smaller aerosurfaces to enable internal carriage on the Air Force F-22 aircraft. The USAF All-Up-Round (AUR) container houses an internal cable which enables up to four missiles to be reprogrammed while in the container. USN containers are not equipped with the cable and must be opened to reprogram the missile. All three AMRAAM variants are currently approved for use on the F-15C/D/E, F-16C/D, and F/A-18C/D aircraft.

Four wings, four fins (control surfaces), and the wiring harness cover are mounted externally, providing additional distinguishing features from other similar missiles, such as AIM-7 Sparrow. The AIM-120C utilizes "clipped" wings and fins in order to meet the internal carriage requirements of the F-22. AMRAAM consists of the following major sections: Guidance, Armament, Propulsion, and Control. Other components include a wiring harness, harness cover, Thermally Initiated Venting System (TIVS), and wing and fin assemblies.

- **Guidance Section, Weapons Guidance Unit.** The Weapons Guidance Unit (WGU) consists of the radome, seeker, servo, transmitter-receiver, electronics unit, Inertial Reference Unit, Target Detection Device (TDD), the harnesses, and frame structure. All units except the TDD are contained within a sealed structure composed of the pyroceramic radome, titanium skin sections, and aluminum aft bulkhead. The TDD, RF and video processor, and the antennas are attached to the aft skin section as a complete testable assembly. Electronics group functions include radar signal processing, seeker servo control, and all of the computations performed in the central data processor. The WGU-16B is used on AIM-120A missiles, the WGU-41/B is used on AIM-120B missiles, and the WGU-44/B is used on AIM-120C missiles. Guidance sections on AIM-120B and AIM-120C missiles contain Electronic Erasable Programmable Read Only Memory which allow reprogramming of the missile software. Missile software versions are denoted by Tape and Revision Numbers, e.g., Tape 4 Revision 16.
- **Armament Section, Weapons Detonation Unit**. The Weapons Detonation Unit (WDU)-33/B forms an integral part of the tactical missile airframe and includes the warhead, the FZU-49/B (modified Mk 3 Mod 5) safe-arm fuze device, and the Mk 44 Mod 1 booster. The armament section also includes the forward missile hook and hanger. The WDU-33/ B warhead meets the Insensitive Munitions (IM) program requirements.

- **Propulsion Section, Weapons Propulsion Unit.** The Weapons Propulsion Unit (WPU)-6/B consists of an airframe, integral rocket motor, a blast tube and exit cone, and an Arm/Fire Device (AFD) with a visible safe-arm indicator. The high performance rocket motor utilizes a reduced smoke, hydroxyl terminated, polybutadiene propellant in a boost sustain configuration, an asbestos-free insulated case (an integral part of the airframe), and an integral aft closure, blast tube, and nozzle assembly with a removable exit cone to facilitate control section installation/removal. Wings are attached in wing sockets at the forward end of the propulsion section. Provisions are included within this section for mounting the filter rectifier assembly.
- **Control Section, Weapons Control Unit.** The Weapons Control Unit (WCU)-11/B consists of four independently controlled electro-mechanical servo actuators, four lithium-aluminum batteries connected in parallel, and a steel fuselage section that is bolted to the propulsion section aft skirt. Each actuator consists of a brushless DC motor ballscrew, an infinite resolution potentiometer directly coupled to the output shaft, and pulse width modulated control electronics. The output shaft is engaged directly to a squib actuated lock so that it does not interfere with the fin (control surface) installation and removal. (5) Wiring Harness, Harness Cover, and Thermally Initiated Venting System. The wiring harness cover extends from the aft end of the guidance section to the forward end of the control section. Its primary purpose is to provide protection for the wiring harness. The main wiring harness electrically connects the umbilical connector, guidance section, and control section. The wiring harness cover also houses the TIVS. The TIVS is designed to vent rocket motor pressure in the event the missile is exposed to a fuel fire. The TIVS consists of an external thermal cord which, when ignited, triggers an Out-Of-Line Device (OOLD) that ignites a Linear Shape Charge that weakens the rocket motor, allowing the rocket motor to vent without exploding. The OOLD prevents the shaped charge from detonating should the booster in the OOLD inadvertently detonate due to causes such as high impact. The unit has an additional safety feature that causes it to “reset” within nine to thirteen units of gravity, such as the acceleration experienced during missile launch. This feature prevents the system from functioning during missile free flight so that the associated aerodynamic pressures do not inadvertently enable the TIVS and thereby degrade missile performance. An indicator is on the wiring harness cover showing the condition of the TIVS, either “ENABLE” or “DISABLE”. Only TIVS equipped missiles are deployed aboard Aircraft Carriers (CV/CVN). The WPU-6/B Propulsion Section (with TIVS) meets the fast cook-off and sympathetic detonation requirements of the IM program and the policy delineated in OPNAV Instruction (OPNAVINST) 8010.13B. The other requirements (bullet impact, fragment impact, and slow cook-off) have not been met with the current configuration. However, the WPU-6/B has been granted the appropriate waivers for shipboard use.
- **Wing and Fin Assemblies.** Wing and fin assemblies provide for flight control of the missile. The four wings are detachable, stationary flight surfaces with ball fasteners to facilitate quick installation and removal. The four fins provide the movable control surfaces. The AIM-120C has “clipped” wings and fins which are not interchangeable with AIM-120A and AIM-120B missiles. The AIM-120C utilizes “clipped” wings and fins in order to meet the internal carriage requirements of the F-22.
- **Launchers**. The AMRAAM system includes three new Missile Rail Launchers (MRLs): the LAU-127A/A, in conjunction with the LAU-115, used on the F/A-18C/D

aircraft; the LAU-128A/A, and the LAU-129A/A, used on the F-15 and F-16 aircraft, respectively. Additional interface cables are not required between the aircraft and the launcher. The MRL can be installed and operated at all current AIM-9 Sidewinder positions on all candidate aircraft, except F/A-18C/D wing tip stations; and is also capable of launching AIM-9 Sidewinder missiles. The MRL supplements the Sidewinder launchers (except F/A-18C/D wing tip) on AMRAAM capable aircraft.

Power for Built-In-Test (BIT) of the pre-launch dormant missile is provided by converting aircraft power in the AMRAAM Electronic Control Unit. The filter rectifier assembly is mounted at the forward end of the missile propulsion section and provides the conversion of aircraft power required by the missile. Prior to launch, signal and data transfer between missile and aircraft is accomplished through a buffer connector that is in-line between the launcher cable and the missile umbilical connector. Similarly, the CFMRE interfaces with AMRAAM using the buffer connector and the missile umbilical connector, and supplies the power in lieu of the aircraft for off-aircraft BIT and reprogramming operations.

Organizational-level maintenance units receive AMRAAM as an AUR, four per container. Organizational-level maintenance is performed by Work Center 230 USN Aviation Ordnanceman (AO) with Navy Enlisted Classification (NEC) codes 8342 and 8842, and USMC personnel with Military Occupational Specialty (MOS) 6531. The AN/AWM-54 Aircraft Firing Circuit Test Set is used to test for stray voltage in aircraft weapons circuits prior to loading ordnance. The AN/AWM-96 Aircraft Weapons Control Test Set is used primarily by Aviation Electronics Technicians (ATs) to test the functionality of the aircraft weapons circuit prior to loading AMRAAM, but is also used by AOs in squadrons employing the Integrated Weapons Team concept. On-aircraft testing is accomplished using the BIT capability of the missile.

AMRAAM Pre-Planned Product Improvement (P3I) missile deliveries are anticipated to begin in FY 00 and continue through FY 12. Under the PrePlanned Product Improvement approach, Phase 2 will incorporate a larger rocket motor, an improved warhead, a quadrant target detection device, an improved electronic safe/arm device and continuously refine the ability to counter threats through Operational Flight Program through the software. Major advantages include:

- A larger rocket motor that will give the missile increased Pk with faster average terminal velocity and better end game capability against maneuvering threats.
- An improved warhead that will give the missile an improved ability to kill the target.
- A quadrant target detection device that will improve the warheads chance of destroying the target.
- Software OFP's will improve the ability of the missile to detect, track and guide on the target.

The 1997 Omnibus bills took $15M from the 3600 funding thereby delaying critical improvements in ECCM. The improvement in the rocket motor is in jeopardy of sliding right by one year. An OSD directive to upgrade air-to-air-ranges (NGTCS) Next Generation Target Control is forcing a $20M AMRAAM budget disconnect requiring the

program redesign of the telemetry unit device for testing. AMRAAM is not currently funded for this activity.
Under the Pre-Planned Product Improvement (P3I) approach, Phase 3 is designed to update the guidance control (seeker). Included with the new seeker, the software will also be continuously updated through Operational Flight Programs (OFP's). Major advantages include:

- Improved missile guidance and Electronic Counter Counter Measures (ECCM) capability.
- Ability to detect, track, and guide to future targets through additional signal path's, control functions, and processing capability.
- Will provide near term improved capability and long term flexibility for threat expansion.
- Will address further guidance control functions to counter current and future threats.

The 1997 Omnibus bills removed $15M from 3600 funding. This impacted the Phase 2 schedule which in turn delayed the Phase 3 work by one year. Without Phase 3, the AMRAAM will not be able to counter future threat aircraft or Electronic Counter Measures employed by the threat.
Phase 3 propulsion is currently unfunded by both USAF and USN. The 1995 AMRAAM COEA stated the +11" rocket motor was the best alternative at the time. Technology has continued to investigate propulsion alternatives. There are currently four different propulsion alternatives being evaluated. The Future Medium Range Air-to-Air Missile (FMRAAM) being investigated by the United Kingdom is also an alternative to AMRAAM propulsion upgrade.

CLAWS [Complementary Low Altitude Weapon System]
HUMRAAM [HMMWV Launched AMRAAM]

In order to successfully execute the OMFTS concept, Marine combat forces will require greater combat effectiveness over larger sectors of the battlespace than is now possible. Marine ground weapons systems today lack mobility because they are heavy, are costly to employ, and impose a significant logistical burden thereby hindering maneuverability courses of action available to the tactical commander. Current ground weaponry technologies simply do not allow the range effectiveness and operational suitability required by the OMFTS concept. The future battlefield will require highly lethal and mobile infantry units. Lightweight and durable weapon systems with improved effectiveness (range, lethality, and accuracy) are needed by Marine Combat Forces. Marine Air-Ground Task Force (MAGTF) must maintain freedom of maneuver to position itself, and the capability to effectively engage the current and emerging air threat

which includes cruise missiles (CM), unmanned aerial vehicles (UAV) and FW/RW aircraft. Current MAGTF ground based air defense consists of Stinger surface to air missiles. Stinger MANPADS and Avenger fire units provide effective close-in low altitude air defense against FW/RW aircraft, but the Stinger missile's range is limited and does not provide reliable cruise missile defense (CMD). The Stinger missile also lacks the ability to engage very low altitude, low cross section targets in clutter.

A new low altitude weapon capability, with extended range and improved effectiveness against the threat, is required to complement the current Low Altitude Air Defense (LAAD) battalion Stinger missile capability. CLAWS (Complementary Low Altitude Weapon System) will provide a rapidly deployable, high fire power, all-weather, stand-off air defense system capable of defeating threat aircraft, CM and UAV's beyond the range of currently fielded Avenger and MANPADS fire units. HUMRAAM, five highly lethal AMRAAM missiles on a mobile HMMWV launcher, is a material solution to the CLAWS requirement.

The primary objective of this task is to adapt the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM) into a ground-to-air missile capability. HUMRAAM will be evaluated with respect to the CLAWS ORD and enhanced as necessary to be compatible with USMC air defense force structure and command control. Technical objectives include: use the Avenger HMMWV as the host platform; develop software for the Expeditionary Air Defense System (EADS) Remote Terminal Unit (RTU) and Ground Based Data Link (GBDL) to support weapon control, acquisition, and launch; receive cueing from all available Marine Air Command and Control System (MACCS) sensors e.g. CWAR, AN/TPS-59, CEC/JCTN.

CLAWS will provide an adjunct to the LAAD battalion that will offset Stinger missile deficiencies, extend SHORDAD engagement range, and provide an effective capability against the cruise missile threat. This low risk concept will maintain the high mobility required for organic protection of maneuver elements.

The requirements for this effort are found in the Mission Need Statement (MNS) for the "Advanced Low Altitude Air Defense Weapon" dated 30 Dec 92, and the "Mobile Surface-to-Air Missile System" dated 9 Feb 93. HUMRAAM directly responds to the Operational Requirements Document (ORD) Number 92364DA: "Complementary Low Altitude Weapon System (CLAWS)" of 18 February 1998.

The CLAWS concept evolved from a AMCOM/RDEC initiative to develop a low cost, high mobility, advanced low altitude missile capability using Horizontal Technology Integration (HTI). The primary goals are to: use an unmodified Avenger HMMWV; be compatible with Avenger force structure and command and control; and be C-130 transportable. AMCOM was the lead agency in a now completed proof-of-concept demonstration of HUMRAAM (FY97).

In August 1997 the first of several live fire demonstrations were condicted using AMRAAM launched from a USMC HMMWV (High Mobility Multi-Wheeled Vehicle--fancy name for an updated Jeep!). The Marines and Army at Redstone Arsenal have been working to put together a highly mobile ground laucher usable by US forces for launching AMRAAMs at cruise missiles, helicopters, and fixed-wing aircraft attacking ground forces, aircraft, POL storage sites, etc. The Marines brought the ground radar, the Army furnished MQM-107 targets, the Navy paid for the range costs, and the Air Force provided the missiles. The first test resulted in a direct hit even though there was no warhead on the missile. In September another test included an Aegis cruiser equipped with CEC (Cooperative Engagement Capability). With the very powerful SPY-1 radar on the ship, linked to a Marine TPS-59 radar on shore, a very accurate air picture was established.

The AMCOM/RDEC proof-of-concept demonstration of a ground launched AMRAAM provided evidence of the feasibility of using the Avenger HMMWV platform, successful integration into EADS (RTU, GBDL), ability to receive cueing from MACCS sensors over existing C3I, and the ability of the AMRAAM missile to engage the required target set. The Marine Corps will conduct a follow-on ATD starting in FY98 that will advance the HUMRAAM development to provide a full-up integration into EADS. AMCOM will deliver 2 HUMRAAM fire units in 2Q FY99 for Marine Corps operational suitability and effectiveness testing.

The HUMRAAM approach will maximize use of NDI including an unmodified AMRAAM missile, Avenger HMMWV, and EADS components such as the RTU. The sophistication of the AMRAAM missile will be exploited to keep the HUMRAAM launcher concept simple. Compatibility will be maintained with the Avenger force structure, especially in the areas of high mobility and manpower requirements. HUMRAAM will use existing MACCS sensors and C3I network assets. An open architecture will be adopted to facilitate interface with emerging fused sensors/data links such as CEC and JCTN.
This ATD project will provide the design and performance data base for the smooth transition into the DEM/VAL phase of projects being transitioned to the MARCORSYSCOM PM. The HUMRAAM effort is fully coordinated with and will transition to the PM for Air Defense (C4IAD). HUMRAAM will be fielded with the LAAD battalion to augment Stinger missile SHORAD capability. By design, HUMRAAM will be compatible with USMC air defense force structure and command

and control. HUMRAAM's horizontal technology approach and use of NDI should facilitate an abbreviated EMD phase resulting in a MS I/II decision by early FY02.

The proposed effort will incorporate advances made from considerable investment and progress under Army, Marine, and Marine Corps programs. HUMRAAM is based on the Army/USMC Avenger fire unit's HMMWV, and the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM) - both active programs. This effort is an outgrowth of AMCOM/RDEC's "Program 559" to develop a high mobility, ground launched version of AMRAAM based on the Avenger HMMWV that would cost $559K. Although AMCOM is the lead agency in the HUMRAAM proof of concept demo, future application within the Army's Forward Area Air Defense (FAAD) structure is uncertain. The Norwegian Air Force has fielded a ground launched version of AMRAAM called the Norwegian Advanced Surface-to-Air Missile System (NASAMS).

The Complementary Low Altitude Weapons System (CLAWS) Program will produce a rapidly deployable, high fire power, all-weather, stand-off air defense system capable of defeating threat aircraft, cruise missiles, and unmanned aerial vehicles beyond the range and capability of currently fielded Marine air defense systems. The CLAWS shall be sufficiently mobile to maneuver with mechanized ground assault forces, carry its own missile ammunition and support equipment, and transform from transport mode to firing mode (and reverse) within mandated time constraints. The CLAWS will be operated by a two-man crew and maintained and supported within current Marine Corps maintenance and support concepts.

The intent of this program is to leverage industry experience with comparable missile programs, as well as independent research and development accomplished by both industry and government, to deploy a "proof-of-concept" capability (e.g., two systems) within an initial twelve (12) month delivery cycle, capable of meeting (minimally) threshold performance requirements. Concurrent with user evaluations and limited testing (e.g., safety, environmental, operational scenarios), two additional production representative systems shall be produced within the following twelve (12) months that exceed threshold performance in key areas, demonstrate operational and supportability improvements, and establish the production configuration baseline. The combined performance period for both phases shall not exceed twenty-four (24) months. Following completion of operational testing and certification, inclusive of rework of the "proof-of-concept" systems, production options for a minimum of twenty-nine systems shall be exercised. The intent of this program is to rely upon proven Non-Developmental and commercial technologies and engineering expertise to achieve program objectives, while allowing the contractor latitude to structure a program commensurate with the maturity of their product and level of confidence in their management/business approach.
The contractor shall deliver two (2) CLAWS "proof-of-concept" units within twelve (12) months of contract award, and, at a minimum, two (2) additional "production representative" systems during the following twelve (12) month period. Production requirements, inclusive of baseline system configuration and quantities, shall be fully defined prior to completion of the twenty-four (24) month schedule. Rework of the "proof-of concept" units shall be included in the twenty-four (24) month performance

period, resulting in a total of four (4) production representative systems. The contractor shall propose and deliver the "proof of concept" missile systems compliant with, at a minimum, the threshold requirements stated in the Performance Specification. The ability of the systems to accomplish anticipated mission requirements and operational scenarios, as well as comply with the overall program schedule shall be supported with empirical evidence. Such evidence (e.g., commercial specifications, performance data, test results, etc.) shall ensure technical compliance of the system to meet performance standards while reducing cost and schedule risk (e.g., reduced testing, improved reliability, etc.). The contractor shall demonstrate that any "value added" capabilities (e.g., demonstrated cost savings or performance/supportability enhancements) exceed threshold performance, reduce total ownership costs, or contribute to improvements in program execution. Similarly, any areas that are non-compliant with performance standards shall also be identified, along with an approach to mitigating impact and achieving operational employment of the system. The scope of this requirement also includes delivery of contractor logistics support and user/maintainer training throughout the pre-production period to assist with initial testing, user validation, and operational capabilities assessments.

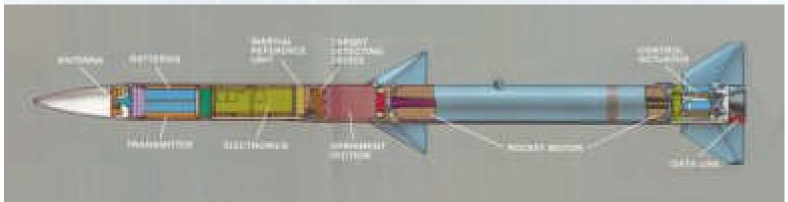
Specifications

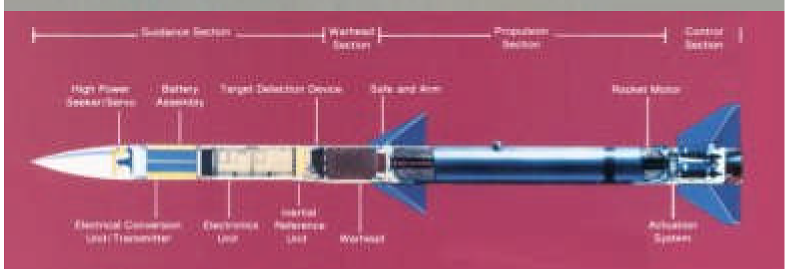
Primary Function	Air-to-air tactical missile
Contractor	Hughes Aircraft Co. and Raytheon Co.
Power Plant	High performance
Length	143.9 inches (366 centimeters)
Launch Weight	335 pounds (150.75 kilograms)
Diameter	7 inches (17.78 centimeters)
Wingspan	20.7 inches (52.58 centimeters)
Range	20+ miles (17.38+ nautical miles)
Speed	Supersonic
Guidance System	Active radar terminal/inertial midcourse
Warhead	Blast fragmentation
Unit Cost	$386,000

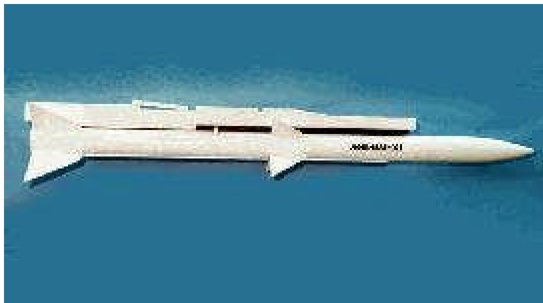
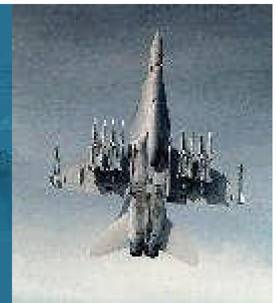
Relative costs of AMRAAM components

Guidance	68%
Control	9%
Fuze	9%
Warhead	2%
Propulsion	6%
Airframe	6%

Date Deployed	September 1991
Aircraft platforms	Navy: F-14D and F/A-18 Air Force: F-15 and F-16 NATO: German F-4, British Tornado and Sea Harrier

















AIM-132 ASRAAM

The Advanced Short Range Air-to-Air Missile (ASRAAM) is a state of the art, highly manoeuvrable and combat effective weapon. Many combat aircraft are currently equipped with radar-guided AIM-120 AMRAAM for long range engagements and the AIM-9 Sidewinder for close combat. The two missiles are an ill-matched pair, since nearly four decades separates their origins. construction. While AMRAAM is highly effective at ranges between 5-50 kilometers, its usefulness diminishes rapidly at a shorter ranges.
A rival to the American-built AIM-9X Sidewinder, ASRAAM is equipped with a Raytheon-Hughes infrared seeker which is the baseline for the company's AIM-9X seeker. The company developed an infrared seeker featuring a unique sapphire dome as part of an engineering-manufacturing-development and production effort valued at $215 million. This ASRAAM seeker played a part the company's competitive win of the AIM-9X missile contract that could lead to some $5 billion in business over the next 20 years.

ASRAAM was initiated in the 1980's by Germany and the United Kingdom, but the two countries were unable to agree on the details of the joint-venture. Germany left the ASRAAM project in the early 1990s, and in the spring of 1995 initiated an improved version of the Sidewinder, the IRIS-T (Infra Red Imagery Sidewinder-Tail controlled) built by Bodensee Geraetetechnik GmBH (BGT). This decision was largely motivated by new insights into the performance of the Russian AA- 11 Archer missile carried by the MiG-29s which Germany inherited during reunification. The Luftwaffe concluded that the AA-11's performance had been seriously underestimated -- the AA-11 turned out to be superior to the Sidewinder AIM-9L in all respects: homing head field of view, acquisition range, maneuverability, ease of designation, and target lock-on. The Germans concluded that the ASRAAM demonstrated a serious lack of agility compared to the Russian Archer.

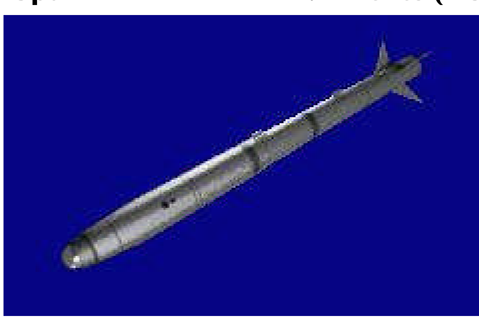
The British Government has spent 636 million pounds (about one billion dollars) since 1992 developing and industrializing ASRAAM. The first ASRAAM was delivered to the RAF [Royal Air Force] in late 1998. It will be used to equip the RAF's Tornado F3 and Harrier GR-7 before the missile becomes the British Eurofighter standard short-range weapon.
In January 1995 British Aerospace Dynamics, Stevenage, Hertfordshire, England, was awarded a letter contract with a ceiling amount of $10,933,154 for foreign comparative testing [FCT] of the ASRAAM Missile. The purpose of the testing is to gather data to determine if the missile meets AIM-9X operational requirements. Work was performed in Stevenage, Hertfordshire, England (50%), Eglin Air Force Base, Florida (25%), and China Lake, California (25%), and was completed by June 1996. The tests focused on the risk areas of the ASRAAM: focal plane array effectiveness, seeker signal processing, warhead effectiveness, rocket motor testing, and kinematic/guidance ability to support the lethality requirements of the AIM-9X. After several modifications to the scope of the FCT, the program assessed four ground-to-air sorties, 19 air-to-air captive carry sorties, four programmed missile launches, eight static warhead tests, and four rocket motor case

tests. The resulting assessment was that the ASRAAM (as is) could not meet the AIM-9X operational requirements in high off-boresight angle performance, infrared counter-countermeasures robustness, lethality, and interoperability. Subsequently, Hughes and BAe proposed an improved "P3I ASRAAM" using thrust-vectoring to provide increased agility and to carry a heavier warhead.

In February 1998 the British-French Matra British Aerospace consortium [formed in 1996] won a multi-million dollar contract to supply the ASRAAM missile to the Australian Air Force to be used on the F/A-18 Hornet. marking the first export sale. The first missiles should be delivered between 1999 and the year 2000.

Specifications

Manafacturer	**British Aerospace**
Date Deployed	**1998 ?**
Range	**8 nm (300 m to 15 km)**
Speed	**Mach 3+**
Propulsion	**One dual-thrust solid-propellant rocket motor**
Guidance	**strapdown inertial and Imaging Infrared**
Warhead	**22.05 lb (10 kg) blast/fragmentation**
Launch Weight	**220.5 lb (100 kg)**
Length	**8 ft, 11.5 in (2.73 m)**
Diameter	**6.6 in (0.168 m)**
Fin Span	**17.7 inches (45 cm)**



Dual Range Missile
Air Superiority Missile Technology (ASMT)

The Dual Range Missile effort is developing and demonstrating guidance and control technologies for enhancing the close-in combat capability of air-to-air missiles. It is also pursuing terminal seekers with extended acquisition range, and advanced propulsion for extended flyout ranges, and technologies for a highly maneuverable missile capable of performing both short and medium range missions. This program is developing and demonstrating guidance and control technologies for enhancing the close-in combat capability of air-to-air missiles. It is also pursuing terminal seekers with extended acquisition range, and advanced propulsion for extended flyout ranges. Enhancement of air-to-air ordnance package performance requires that the target detection device and warhead burst point calculations use all information available to the missile. Effective coupling of the warhead energy onto the target requires improvements in directing the kill mechanism so that as much of the kill mechanism as possible investigation of such concepts as guidance integrated fuzing, advanced fuze sensors, and advanced guidance and control technologies. Technologies such as reaction jets will reduce the need for missile fins, providing compressed missile carriage which will double missile loadouts for a given carriage volume.

Improvements in enemy aircraft technology and the proliferation of advanced aircraft have resulted in nations possessing fighter aircraft nearly equal to American systems. The weapons suite for these aircraft is in some areas (e.g., aerodynamics) superior to current US systems. In 1990, Air Force Research Laboratory's Munitions Directorate engineers realized the importance of developing revolutionary air to air missile flight control technologies to counter a new breed of highly effective, very maneuverable international weapons being fielded by potentially unfriendly nations.

The program started in 1992 to explore current and future missile technologies with the goal of greatly improving air to air missile effectiveness against highly capable threats. Extensive trade studies, wind tunnel testing, and manned air combat simulations were completed to select the highest payoff missile control techniques to be incorporated into this next generation missile.

In June 1997 McDonnell Douglas received a contract in June to develop technology for a new air-to-air missile. The award was made under the U.S. Air Force's Air Superiority Missile Technology (ASMT) program. During the five-year, $22 million program, the company will design, develop and demonstrate an advanced flight control system that will allow a single missile to perform both close-in and beyond-visual-range air-to-air

missions. The dual-range capability of the missile results from a hybrid combination of flight control and propulsion technologies for both short and longer range missiles.

The missile's advanced electronically steered seeker allows quick target lockon at extremely large offboresight angles. Pilots are able to launch missiles 'overtheshoulder' at trailing adversaries, while maintaining straight and level, high speed flight, enhancing their survivability. The ability to quickly capture and maintain angles of attack exceeding 90 degrees enables the missile to turn to the rear only two seconds after launch. Not only does this quick turn rapidly orient the missile toward the target, but it allows the majority of the missile's fuel to be used to accelerate toward the target.

The new flight control system combines small, side-thrusting reaction jets integrated into the aft section of the main rocket motor with small (reduced-span) tailfins. The jets, which bleed propulsive gas from the rocket motor, are used when high levels of agility are required to engage a threat.

Advanced Air-to-Air Missile (AAAM) Outer Air Battle Missile

During the 1980s the Navy invested in developing the Phoenix into a robust, long-range, high-energy weapon system, and in the late 1980s embarked on a program to develope an improved follow-on capability in the Advanced Air-to-Air Missile (AAAM). Advanced Common Intercept Missile Demonstration (ACIMD) tests demonstrated the technology and hardware for a highly advanced Sparrow-sized, integral-rocket-ramjet-propelled, multimode-guided air-to-air missile for the long-range outer-air battle. The Navy planned to maintain and support an adequate Phoenix missile capability until the AAAM is fielded in sufficient numbers. A missile retrofit program incorporating an already developed and demonstrated block upgrade to the AIM -54C was a cost-effective interim solution. As of 1990 it was estimated that it would require at least 10 years to introduce the follow-on Advanced Air-to-Air Missile.

With the end of the Cold War there was a general recognition that the outer air battle -- the battle against Soviet naval aviation bombers -- was significantly reduced in importance. While AAAM was seen as the best defense against the Soviet naval air arm, the future threat would consist of Third World fighter-bomber or diesel-electric submarine. This changing security environment doomed this Phoenix missile successor [as well as the associated F-14D Super Tomcat upgrades], and the Advanced Air-to-Air Missile program was cancelled in 1992.

FIM-92A Stinger Weapons System: RMP & Basic

The Stinger missile, a full-dimensional protection weapon, is the Army's system for short-range air defense that provides the ground maneuver commander force protection against low-altitude airborne targets such as fixed-wing aircraft, helicopters, unmanned aerial vehicles, and cruise missiles. The Stinger is launched from a number of platforms: Bradley Stinger Fighting Vehicle, Bradley Linebacker, Avenger (HMMWV), and helicopters as well as Man Portable Air Defense (MANPADS).

The Stinger is a man-portable, shoulder-fired guided missile system which enables the Marine to effectively engage low-altitude jet, propeller-driven and helicopter aircraft. Developed by the United States Army Missile Command, the Stinger was the successor to the Redeye Weapon System. The system is a "fire-and-forget" weapon employing a passive infrared seeker and proportional navigation system. Stinger also is designed for the threat beyond the 1990s, with an all-aspect engagement capability, and IFF (Identification-Friend-or-Foe), improved range and maneuverability, and significant countermeasures immunity. The missile, packaged within its disposable launch tube, is delivered as a certified round, requiring no field testing or direct support maintenance. A separable, reusable gripstock is attached to the round prior to use and may be used again. STINGER will also be employed by the Pedestal-Mounted Stinger Air Defense Vehicle and the Light Armored Vehicle, Air Defense Variant (LAV-AD) during the 1990s.

During the 1960s the Marine Corps introduced its first lightweight shoulder fired surface-to-air missile, the Redeye. During June 1966 the Redeye school was activated at Marine Corps Base, 29 Palms California. By Sept. 1966, a Redeye platoon was placed in each stateside Marine division. This gave Marine commanders a viable air-defense capability that could be deployed to any area of the battlefield.

The Redeye missile served throughout the 1970's before giving way to the more technologically advanced Stinger missile in 1982. The Stingers "all aspect" engagement capability was a major improvement over the Redeye. In 1989 an improved Stinger, equipped with a reprogrammable microprocessor (RPM), was fielded by the Marine Corps. The RPM is a modular enhancement which allows the Stinger to engage and destroy more sophisticated air threats.

There are currently four configurations of the Stinger missile. They are: Stinger Basic, Stinger Passive Optical Seeker Technique (POST), Stinger Reprogramable Micro Processor (RMP), and Stinger RMP Block I.

The two upgrades to the Stinger-RMP (reprogrammable microprocessor) missile correct known operational deficiencies. Manpower and readiness problems plagued the Army force modernization program in the early 1980’s. It seemed that whenever a new system was put into the hands of the soldier, actual field performance often failed to match the

standards predicted during its development. The Stinger anti-aircraft missile, for example, was designed to hit incoming aircraft better than 60 percent of the time. But if it had been placed in service as originally designed, it would actually have achieved hits only 30 percent of the time when operated by soldiers in combat units. The Stinger's problems were eventually corrected. Operational deficiencies were discovered during testing of the Stinger-RMP missile in the late 1980s, and the Secretary of Defense directed the Army to correct the deficiencies and then operationally test the fixes. The proposed operational test, which consisted of 24 missile firings, was approved by DOT&E via the TEMP in 1991. The Stinger-RMP missile test program was suspended during OPERATION DESERT STORM, and the missile was rushed into the field in preparation for war. After the war, the Army proposed a two-phased upgrade program, Stinger-RMP Block I and Stinger-RMP Block II. The Stinger-RMP Block I missile consisted of hardware and software modifications, which address some of the observed operational deficiencies. The Stinger-RMP Block II will address remaining operational issues.

The **Stinger-RMP Block I** makes software and hardware changes, including a new roll frequency sensor, a small battery, and an improved computer processor and memory. The Block I missile upgrades the RMP missile by adding a ring laser gyro to eliminate the need to super elevate prior to firing. The Block I missile also increases the onboard processing capability and replaces the current battery with a lithium battery. Block I improves the accuracy and IRCCM capabilities of the missile. The Army proposes to field more than 10,000 Stinger-RMP Block I missiles that will remain in the inventory until at least 2014.

Stinger-RMP Block II improves both hardware and software, including an advanced imaging focal plane array, roll frequency sensor, new battery, signal processing, and advanced software. There are plans to produce approximately 9,500 Stinger-RMP Block II missiles. The Milestone III decision to authorize production of the Stinger-RMP Block II missiles in 2004 was to be supported by operational testing. The last approved TEMP is dated 1 March 1991. Fifteen Test events occurred between 1993-1996 to verify Stinger-RMP Block I hardware and software improvements. A TEMP revision dated January 27, 1995 was not approved by OSD.

The Fiscal Year 2001 Army budget request included decisions to restructure or "divest" a number of programs in order to provide some of the resources to support its transformation to achieve the ambitious deployment goals outlined in the October 1999 Army Vision. The restructured programs are the Crusader and the Future Scout and Cavalry System. The "divestitures" include Heliborne Prophet (Air), MLRS Smart Tactical Rocket (MSTAR), Stinger Block II, Command and Control Vehicle (C2V), Grizzly, Wolverine, and the Army Tactical Missile System Block IIA. Funding for these programs was reallocated to fund the Army Vision transformation strategy.

The **Air-to Air Stinger [ATAS]** is an adaption of the man portable Stinger System. It is a light weight missile designed to engage low altitude targets. A major milestone in the improvement of the Air-to-Air Stinger (ATAS) Block-1 missile was demonstrated on 19 November 1996 at Yuma Proving Ground, AZ. An OH-58D piloted by CPT Bob Blanchett, US Army Test and Evaluation Command (TECOM), successfully acquired, tracked, engaged, and destroyed a QUH-1 drone helicopter deploying countermeasures at a range greater than 4500 meters. This firing also demonstrated the capabilities of the

improved missile to successfully engage a target without the requirement for super-elevation.

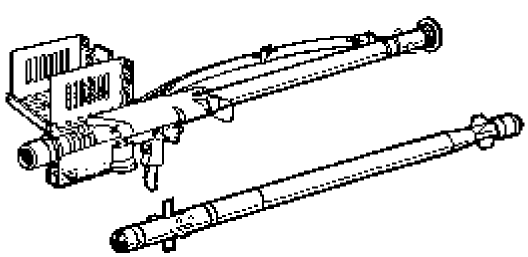
All **Air-to-Air Stinger (ATAS) Block II** missiles will be modified existing Stinger RMP missiles. The Block II retrofit program will add the Block I modifications plus incoporate a starring IR focal plane array seeker, a new battery, and advanced signal processing capabilities. The new seeker will permit engagements of helicopters in clutter out to the kinematic range of the missile. The missile and launcher will be 1760 compatible. The Block II program will also extend shelf, improve accuracy and IRCCM capabilities, and will provide a full night capability.

The first Stinger Reprogrammable Micro Processor (RMP) missile was successfully fired by a Kiowa Warrior while acquiring the target through the seeker slaving mode at Yuma Proving Ground on 6 November 1997. This mode of acquiring the target dramatically simplifies the procedure and should decrease the acquisition/engagement time lines in most instances. Essentially, the system slews the Stinger missile's seeker to an off-axis position coincident with the Mast Mounted Sight's (MMS) line of sight (LOS). Considering the missile seeker's relatively small field of view, the capability to accurately direct the seeker onto a target being tracked by the MMS is a significant advantage. In practicality, the pilot no longer has to meticulously fly the missile to the target by aligning the center cross with the MMS LOS cue. He merely flies the aircraft to the "ballpark" of the MMS LOS and initiates first detent, allowing the seeker to slew to the target, uncage and begin tracking it. This capability will afford the greatest advantage while acquiring from a hover position in unstable wind conditions with the RMP missile. Seeker slaving is enabled by the Improved Master Controller Processor Unit (IMCPU) which is included with the digitized Kiowa Warriors. Non-digitized Kiowa Warriors may be equipped with seeker slaving by adding a card in the Integrated System Processor. Eventually, all Kiowa Warriors will gain seeker slaving as they are converted to the digital configuration.

Specifications

Primary function	To provide close-in, surface-to-air weapons for the defense of forward combat areas, vital areas and installations against low altitude air attacks.
Manufacturer	Prime - Hughes Missile System Company Missile - General Dynamics /Raytheon Corporation
Propulsion	Dual thrust solid fuel rocket motor
Length	5 feet (1.5 meters)
Width	5.5 inches (13.96 centimeters)
Weight	12.5 pounds (5.68 kilograms)
Weight fully armed	34.5 pounds (15.66 kg)
Maximum system span	3.6 inches (9.14 cm)
Range	1 to 8 kilometers

Sight ring	10 mils
Fuzing	Penetration, impact, self destruct
Ceiling	10,000 feet (3.046 kilometers)
Speed	Supersonic in flight
USMC Units	Low-Altitude Air Defense (LAAD) Battalions: 3 active duty, 2 reserve
Crew	2 enlisted
Guidance system	Fire-and-forget passive infrared seeker
Warheads	High explosive
Rate of fire	1 missile every 3 to 7 seconds
Type of fire	"Fire-and-Forget"
Sensors	Passive infrared
Introduction date	1987
Full-rate production	3QFY94
Unit Replacement Cost	$38,000
Total program cost (TY$)	1060 systems $7281M
Average unit cost (TY$)	$6M
Inventory	~13,400 missiles

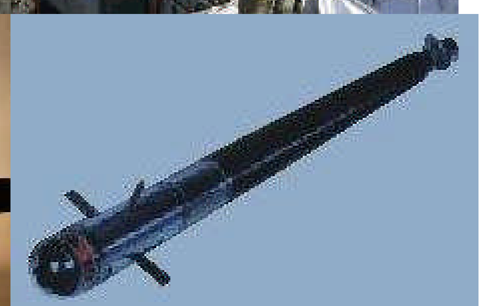











Hydra-70 Rocket System

The HYDRA 70 (70mm) Rocket System is a family of 2.75" unguided rockets.The 2.75 inch Folding-Fin Aerial Rocket (FFAR) was originally developed by the US Navy for use as a free-flight aerial rocket in the late 1940s. Used during both the Korean and Vietnam wars, their role has expanded to include air-to-ground, ground-to-air, and ground-to-ground. The 2.75 inch rocket system has a rich history of providing close air support to ground forces from about 20 different firing platforms, both fixed-wing and armed helicopters, by all US armed services. When the requirements of this system were changed to a new air-to-ground role for fixed and rotary wing aircraft, new fuzing and warhead performance characteristics, as well as a modified motor for low speed aircraft became necessary. The HYDRA 70 family of rockets was designed to fill this role. The Hydra 70 rocket system is used by US Army Special Operations Forces, the US Marine Corps, the US Navy, and the US Air Force. The Hydra-70 rocket is fired from all armed Army Helicopters and the armed helicopters of most sister services. The rocket is also fired from many U.S. fixed wing platforms and is a major export munition to many allied nations. The Army's Hydra-70 PM at Rock Island, IL is assigned as the single item manager responsibile for meeting the rocket needs of all users.

The war reserve unitary and cargo warheads are used for anti-materiel, anti-personnel, and suppression missions. The Hydra 70 family of Folding-Fin Aerial Rockets (FFAR) also includes smoke screening, illumination, and training warheads. These rockets are used by rotary, wing, fixed and ground platforms. The most widely used application is on helicopters for air-to-ground engagements.

In the US Army, Hydra 70 rockets are fired from the AH-64A Apache/AH-64D Apache Longbow using M261 19-tube rocket launchers, and the OH-58D Kiowa Warrior and the AH-1F "modernized" Cobra using seven-tube M260 rocket launchers. The AH-1G Cobra and the UH-1B "Huey" used M200 19-tube rocket launchers. The Navy uses the 19 round LAU-61C/A and the seven round LAU-68 D/A rocket launchers. These reusable launchers have an external thermal coating that greatly prolongs cook-off protection time. Full production of these launchers began in June 1985.

To provide some stability the four rocket nozzles are scarfed at an angle to impart a slight spin to the rocket during flight. The modified motor provides increased stand-off range and reduced ballistic dispersion. The MK 66 rocket motor was designed to provide a common 2.75-inch rocket for helicopters and high-performance aircraft. Compared to the MK 40 motor, it has a longer tube, an improved double base solid propellant, and a different nozzle and fin assembly. Increased velocity and spin provide improved trajectory stability for better accuracy. The launch signature and smoke trail have been significantly reduced. The MK 66 Mod 1 is not hazards of electromagnetic radiation to

ordnance safe. It can be inadvertently ignited by electromagnetic radiation, especially by radio frequencies found aboard Navy ships. Both the Mod 2 and Mod 3 have HERO filters, and the Mod 2 filter may prevent the AH-1 rocket management system from inventorying. The Mod 1 is the standard motor for Army use as will be the Mod 3 when it is fielded.

The HYDRA-70/2.75 Inch Rocket System is managed by Project Management Office, 2.75-Inch (70mm) Rockets. This office is a new Project Management Office, effective 01 October 1997. The 2.75"/HYDRA Rocket Acquisition Team received the Secretary of the Army Award for Excellence for Systems Contracting at a ceremony on 14 December 1998. Currently, General Dynamics is the general contractor for the rocket system and Thiokol produces flare rockets.

Components

The HYDRA-70 Rocket System is the Army name for the improved 2.75 Inch Rocket System and includes the following items:

- M260/M261 Light Weight Launchers (LWLs)
- MK66 Rocket Motor, Mods 1, 2, & 3
- M151 (10 lb) HE Warhead with M423 PD Fuze
- M229 (17 lb) HE Warhead with M423 PD Fuze
- M255A1 Flechette Warhead with M439 RS Fuze
- M257 Illumination Warhead with M442 Fuze (delay)
- M261 MPSM/HE Warhead
- M264 Smoke Screening (RP) Warhead with M439 Fuze
- M267 MPSM Practice Warhead
- M274 Smoke Signature Practice Warhead
- M278 IR Flare Warhead with M439 RS Fuze

The **M260 Light Weight Launcher** is a seven-tube launcher.

Configuration	**Center of Gravity (In Inches from Front)**	**Weight (lbs)**
Empty	35.2	35.2
M229/M423/MK66 (HE)	25.3	196.2
M151/M423/MK66 (HE)	32.9	202.5
M151/M433/MK66 (HE)	32.3	317.7
M257/MK66 (Illumination)	28.9	205.0
M264/MK66 (Smoke)	31.8	192.7
M261, M267/MK66 (MPSM)	28.4	225.6

M255A1/MK66 (Flechette)	28.4	225.6
M274/MK66 (Practice)	32.9	196.2

The **M261 Light Weight Launcher** is a nineteen-tube launcher.

Configuration	**Center of Gravity (In Inches from Front)**	**Weight (lbs)**
Empty	35.8	82
M229/M423/MK66 (HE)	27.2	660
M151/M423/MK66 (HE)	33.1	518
M257/M442/MK66 (Illumination)	29.0	542
M264/M439/MK66 (Smoke)	32.4	493
M261/M439/MK66 (MPSM)	28.5	598
M255A1/M439/MK66 (Flechette)	28.4	604
M274/MK66 (Practice)	32.9	516.0

The **MK66 motors** use a longer motor tube (than the older MK40/MK4), that is of a different aluminum alloy, and is assembled with a new fin and nozzle assembly. The fins are of a spring loaded, wrap around design, and are attached around the circumference of the single nozzle. The propellant grain is longer and of a different formulation than that of the MK40/MK4, however, the stabilizing rod and igniter are essentially the same design. The MK66 motors have a substatially higher thrust, 1335 lbs, and a longer range than the older motors. The current generation of the MK66 in use by the U.S. Armed Services are the MK66 MOD 3 for the Army, and the MK66 Mod 2 for the Air Force, Navy, and Special Operations Force. The MOD 3 incorporates a Hazard of Electromagnetic Radiation to Ordnance (HERO)safe electronic RF filter in the igniter circuit. The RF filter is mounted onto the igniter can and allows the aircraft's direct current firing pulse to pass to the igniter squib, but absorbs and dissipates RF energy. The RF filter does not change the electrical resistance of the firing circuit. Electromagnetic Test Report SR-RD-TE-87-43 dated 8 May 1987 documents the HERO suitability of the MK66 MOD 3 motor. A brass EMR shield is used over the fin and nozzle to prevent the DC energy produced by the eletrical arcing encountered when loading motors into launchers in high intensity RF fields from igniting the motor. These shields are furnished with the MOD 3 motor and should be retained for unloading rockets. Due to the shipboard concern of Foreign Object Damage (FOD), the other Armed Services use the MOD 2 motor. The MOD 2 contains a Dahlgren Bridge Assembly (DBA) for a HERO filter. The DBA is a wheatstone bridge designed to prevent the RF of concern from igniting the motor. It consists of two stainless steel wires and two copper core, stainless clad wires of proper resistance crimped together. The alternating current induced by the RF is shunted around the igniter squib. The MOD 2 motor uses a stabilizing rod that is hollow core that acts as a conduit for the igniter wires. The DBA increases the resistance

of the motor from 0.7 - 2.0 ohms to 2.3 - 3.0 ohms. This additional resistance can cause the fielded aircraft fire control to err during inventory of available rockets.

The MOD 4 motor is a new design that will become common to all Armed Services and eliminates the undesirable traits of the previous designs. The first deliveries of the MOD 4 motor will be in 1998. The purpose of the MK 66 MOD 4 Rocket Motor is to improve several safety (specifically E3) deficiencies of the MK 66 MOD 2 Rocket Motor. The MOD 4 motor incorporates a new initiator (MK 26 MOD 0), igniter (MK 311 MOD 0), and E3 filtering. As a result, the MK 66 MOD 4 Rocket Motor is HERO, 300 KV and 25 KV ESD, and EMP safe. The E3 filtering includes a capacitor under the nozzle and two low pass filters located on the igniter and in the initiator. Also, a natural spark gap also exists between the contact band and nozzle body. The bare MK 66 MOD 4 Rocket Motor does not function when exposed to 300,000 volts of Electrostatic Discharge (ESD). During testing, as a worst case test, the U.S. Government forced the charge from the 300 KV ESD to hit the rocket motor contact band (firing contact). The filters reliably diverted the ESD pulse away from the initiator. The MK 26 MOD 0 Initiator, the MK 311 MOD 0 Igniter, and the MK 66 MOD 4 Rocket Motor pass 25 KV ESD (human generated electrostatic discharge). The MK 66 MOD 4 Rocket passed HERO testing using the Apache and Blackhawk helicopters as the test platforms. These helicopters are considered to present the worst case for HERO testing. HERO safe certification exists in letter DD/NSWC 8020 F52-RDD dated 13 April, 1995. EMP analyses on the MK 66 MOD 4 Rocket Motor shows it has an EMP factor of safety of over 35 million. This is because the EMP pulse is extremely short (3 microseconds). The short pulse does not provide enough energy to heat the MK 26 MOD 0 Initiator bridgewire.

MK66 Rocket Motor Data

Weight, shipped: 13.6 lbs
Burn time: 1.05 - 1.10 sec
Average thrust (77 F):
1300-1370 lb
Impulse (77 F):
1472 lb/sec
Motor burnout range:
1300 ft (397 m)
Motor burnout velocity:
2425 fps
Launch spin rate: 10 rps
Velocity at launcher exit:
148 fps
Acceleration:
60-70 G (initial)
95-100 G (final)

Igniter resistance: 0.7 - 2.0 ohms
Propellant Type: Extruded
double base
ethylcellulose inhibited,
cartridge loaded
Propellant weight: 7 lb
Propellant configuration: 8
point internal
burning star
Temperature limits:
Storage: -65 F to
+165 F
Operation: -50 F to
+150 F

HYDRA-70 Warheads can be categorized into two areas. Unitary warheads are fitted with impact detonating warheads. Cargo warheads, with airburst range setable or fixed

stand-off fuzes, utilize the "wall-in-space" concept. The "wall-in-space" concept provides an extremely large increase in effectiveness and virtually eliminates range-to-target errors due to variations in launcher/helicopter pitch angles during launch. The M439 Fuze is remotely set from the aircraft with time (range) to the target data. After firing, the initial forward motion of the rocket begins fuze functioning at the computer-determined time (at a point slightly before and above the target area), the M439 Fuze initiates the expulsion charge. The submunitions (SMs) are ejected, and each Ram Air Decelerator (RAD) inflates. This separates the SMs, starts the arming sequence, and causes each SM to enter into a near vertical descent into the target area. Similarly, the payload of the M267 is discharged to deploy the three M75 Practice SMs.

The **M151 HE Warhead** is the 10-pound anti-personnel warhead -- traditionally referred to as the "10 Pounder" -- which was designed and developed by the Army and is currently in production. It consists of two main parts, the nose and the base, which are welded (brazed) together. The bulk of the lethality is obtained from the nose section which is fabricated using nodular, pearlitic malleable cast iron. The nose end of the warhead is threaded to receive the M423 Fuze. The M151 can be used M423, M429, and M433 fuzes. The base section is fabricated using steel or cast iron and is threaded for attachment to the rocket motor. The total weight of the loaded, unfuzed, warhead is 8.7 pounds (3.85 kg), of which 2.3 pounds (1.04 kg) is composition B-4 High Explosive (HE). Upon detonation, the warhead fragments into thousands of small, high velocity fragments. The bursting radius is 10 meters; however, high velocity fragments can produce a lethality radius in excess of 50 meters. Temperature limits for storage and firing the M151 are -65 F to +150 F.

The **M156 White Phosphorous (Smoke)** is primarily used for target marking and incendiary purposes. It ballistically matches the M151 and is of similar construction. Filler for the M156 is 2.2 pounds of WP with a .12-pound bursting charge of composition B. The approximate weight of the fuzed warhead is 9.7 pounds. The M156 uses M423 and M429 fuzes.

The **M229 HE Warhead** is an elongated version of the M151 Warhead and is commonly referred to as the "17 Pounder" warhead. The M229 HE warhead is currently in the inventory. It was designed and developed to increase the lethality and destructiveness of the 10 pound high explosive warhead. The total weight of the loaded, unfuzed warhead is 16.1 pounds (7.3 kg) [other sources report an unfuzed weight of 16.4 pounds] of which 4.8 pounds (2.18 kg) is composite B-4 HE. Upon detonation, the warhead fragments into thousands of small, high velocity, fragments. Temperature limits for storage and firing the M229 are -65 F to +150 F.

The **M247 High-Explosive** M247 is no longer in production; however, some of these warheads may still be found in war reserve stockage. With a shape charge for an antiarmor capability, the M247 employs a cone shaped charge like that of the M72 LAW. The point initiated detonating fuze (M438) is an integral part of the warhead. The weight of the M247 is 8.8 pounds, of which 2.0 pounds is composition B.

The **M255A1 Flechette Warhead** design results from a program to develop an air-to-air/air-to-ground warhead with a payload of 1,179 60-grain flechettes. This warhead was type classified standard (for SOF only) and fielded in 1993. The warhead uses many standard components with the M261/M267 Warhead, such as the plastic nose cone, aluminum case, umbilical cable, and the M439 RS Fuze. The M255A1 is intended to be used against light material and personnel targets. At expulsion the flechettes separate and form a disk like mass which breaks up with each flechette assuming an independant trajectory, forming a repeatable dispersion pattern. The flechette uses kinetic energy derived from the velocity of the rocket to produce the desired impact and penetration effect on the target.

The **M255E1 Flechette** flechette warhead, which contains approximately 1,180 60-grain hardened steel flechettes, is in limited production. It is designed for use with the M439 fuze and has possible air-to-air as well as air-to-ground application.

The **M257 Illumination Warhead** with M442 Fuze (delay) was designed for battlefield target illumination. The flare warhead is assembled to the MK66 Rocket Motor in the field. The flare and rocket can be launched from either fixed-wing or rotary-wing aircraft. The M257 consists of an ignition system, flare, main parachute, drogue parachute assembly, and an integral fuze and delay assembly. The warhead is enclosed in an aluminum case. The setback-actuated fixed time integral fuze provides a standoff distance of approximately 3,000 meters. The arming fuze and delay assembly is actuated by motor acceleration. The rocket is fired from the helicopter to attain elevation between 2000 and 4000 feet at 3000 meters downrange. An M442 integral fuze provides a standoff range of approximately 3,000 meters with the MK 40 motor and approximately 3,500 meters with the MK 66 motor. The M257 candle descends at 15 feet per second, burns for approximately 100 seconds with a minimum light output of one million candle power. It can illuminate an area in excess of 1 square kilometer at optimum height. The weight of the M257 is 10.8 pounds, of which 5.4 pounds is magnesium sodium nitrate.

The **M261 High-Explosive Multipurpose Submunition [MPSM]** warhead provides improved lethality against light armor, wheeled vehicles, materiel, and personnel. The M261 is a cargo warhead consisting of a nose cone assembly, a warhead case, an integral fuze, nine M73 submunitions, and an expulsion charge assembly. The nose cone assembly, a plastic cone bonded to a metal cup-shaped base, is attached to the body by shear pins. The body is a hollow cylinder loaded with 9 full caliber multipurpose submunitions (MPSM). Each submunition has a Ram Air Decelerator (RAD), folded, which nests into the shaped charge cone of the submunition ahead; the 9th (forward) submunition nests into the forward cup which makes up the base of the nose cone. A metal pusher plate is located just aft of the submunition cargo stack and is forward of the expulsion charge assembly. The threaded end of the body is machined internally to accommodate a base detonating, remote settable, variable range fuze. The 9 High Explosive (HE) submunitions are deployed by initiation of a 5.5 gram expulsion charge, consisting of 80% M10 double base probellant and 20% Class 6 black powder. The expulsion charge is initiated by an M84 electric detonator contained in the M439 fuze. A pusher plate then ejects the stack of submunitions through the nose cone. The primary warhead fuze, M439, is remotely set with the ARCS, MFD, or RMS to provide range settings (time of flight) from 500 meters to approximately 7,000 meters. On the AH-1, the RMS is programmable only from 700 meters to 6,900 meters.

The expulsion charge is initiated at a point before and above the target, approximately 150 meters, depending on the launch angle. The submunitions are separated by ejection, and arming occurs when the ram air declarator deploys. The RAD virtually stops forward velocity and stabilizes the descent of the submunition. An M230 omnidirectional fuze with an M55 detonator is used on each submunition and is designed to function regardless of the impact angle. Each submunition has a steel body that has a 3.2-ounce shaped charge of composition B for armor penetration. The submunition is internally scored to optimize fragments against personnel and materiel. Upon detonation, the shaped charge penetrates in line with its axis and the submunition body explodes into high velocity fragments (approximately 195 at 10 grains each up to 5,000 feet per second) to defeat soft targets. The fuzed weight of the M261 is 13.6 pounds. At shorter ranges, the RAD takes longer to overcome momentum, increasing dispersion. As range increases, the rocket loses momentum, increasing the effectiveness of the RAD. This increased effectiveness reduces submunition drift and ground dispersion. Forestation, other vegetation, and natural or man-made structures within the target area may cause the submunition to detonate or land in a non-standard dispersion pattern. Aerodynamic forces affecting submunitions during vertical descent may prevent them from landing upright (0 degrees off center). Sixty-six percent of the time a submunition will land 5 degrees off center; 33 percent of the time a submunition will land 30 degrees off center. Each M73 HE submunition has a shaped charge that can penetrate in excess of 4 inches of armor. A submunition that lands 5 degrees off center has a 90-percent probability of producing casualties against prone, exposed personnel, within a 20-meter radius. A submunition landing 30 degrees off center has a 90-percent probability of producing casualties within a 5 meter radius.

The **M264 RP Smoke** is used as a red phosphorus (RP) filled smoke rocket propelled by the MK66 motor and functions at a remote settable range from 1000 to 6000 meters. Upon functioning, the M439 Fuze ignites the expulsion mix, which simultaneously ignites and ejects the 5 pound RP payload through the shear-pinned nose cone. The burning RP drops to the ground producing a voluminous cloud of white smoke. Fourteen M264 rockets will screen a 300-400 meter front with a 5-10 knot wind from the unaided eye for a minimum of 5 minutes. The RP pellet stack assembly consists of 72 RP pellets arranged in 18 rows of 4 each and are separated by felt pieces impregnated with a phosphine gas absorbent mixture, manganese dioxide/cuprous oxide.

The **M267 Practice** round is a physical and ballistic match and is identical in operation to the M261 MPSM HE Warhead except that three M75 Practice SMs, with a flash powder smoke signature and six inert SM load simulators, take the place of the nine M73 SMs in the M261 Warhead. The M67 uses the M439 RS Fuze. Each practice submunition contains approximately 1 ounce of pyrotechnic powder. An M231 fuze with an M55 detonator is used with practice submunitions.

The **M274 Smoke Signature Practice Warhead** is an identical flight match for the M151 to provide training with a smoke signature upon impact during practice firing. It consists of a modified warhead casing (WTU-1/B) with vent holes, an M423 Fuze Safe and Arming (S&A) device, and a smoke cartridge to provide the signature flash. A cylindrical cartridge assembly is in the forward section of the casing; it contains

approximately 2 ounces of potassium perchlorate and aluminum powder that provides a "flash, bang, and smoke" signature. The M274 weighs 9.3 pounds.

The **M278 IR Flare Warhead** with M439 RS Fuze warhead was designed for battlefield target illumination in conjunction with Infrared (IR) goggles. The flare warhead is assembled to the MK66 Rocket Motor in the field. The flare and rocket can be launched from either fixed-wing or rotary-wing aircraft. The M278 provides an average near IR light output of 250 watts/steradian and less than 2K candle power of visible light with a desired goal of 1K candle power. The IR flare will provide IR light for 3 minutes. Time to candle ignition from launch is 13.5 seconds.

The **M439 Fuze** consists of an electronic module and a safe and arming device. The safe and arming device contains the M84 electric detonator in a shorted condition, disconnected from the electric firing circuit, and mechanically out of line with the expulsion charge. The rotor containing the detonator is locked in the out of line condition by a spring-loaded setback weight. Acceleration of 12 g is required to unlatch the rotor. Rotor motion is controlled by a run-away escapement which requires sustained acceleration greater than 24 g for more than 0.6 seconds in order to bring the detonator into the armed condition, i.e., unshorted, mechanically in line, and connected to the electric firing circuit. In the armed condition, the detonator may be fired by an electric impulse from the electronic module. However, in order to produce a firing pulse, the fuze must have had its power supply and firing capacitor charged from an external power source through the co-axial fuze charge line which extends from the ogive of the warhead.

The **M84 detonator** contains an ignition charge of 5 mg of lead styphnate, an ignition charge of 65 mg of lead azide, and a base charge of 65 mg of PETN. It is a low impedance (2 to 5 ohm) bridge wire device requiring 500 ergs of energy to fire.

Upgrades

Plans for improving the system and continuing its growth potential are predicated on certain key objectives and requirements to the following:

- **Improving System Accuracy**: Development of the MK66 Wrap-Around Folding Fin Aircraft Rocket Motor and integration of new Light Weight Launchers (LWLs) with inproved fire control systems.
- **Increasing System Versatility and Effectiveness**: Development of the MK66 Motor; the M261 MPSM; the M439 Remote Range Set Fuze; the M151 HERS Fuzed Warhead; the M255A1 and Air-to-Air Flechette (ATAF) Warhead; the M264 Smoke Screening Warhead; M257 Illumination Warhead; and M278 Infrared (IR) Flare Warhead.
- **Reducing Number of Major Components**: No repair parts needed for the new M260 and M261 LWLs.
- **Enhancing Employment Simplicity**: Compatability of RS fuzes with new laser range devices and rocket system.
- **Increasing Tri-Service Standardization**: Standard compatability of HYDRA-70 components with equipment from all services.

The HYDRA-70 family of rockets can now fill a variety of roles. A multipurpose Submunition (MPSM) Warhead, when added to the new motor, provides reduced range dispersion and improved system lethality. The HYDRA-70 High Explosive Remote Set (HERS) Rocket provides an aircraft with a Remote Set (RS), multi-option capability for use against canopy or bunker penetration targets, as well as against targets in the open. An RS flechette warhead was recently fielded for the SOF. Screening smoke and both visible and infrared (IR) illumination are available for supportive missions.

The Navy's Advanced Rocket System planned in the late 1980s to "neckdown" the 2.75-Inch and 5-Inch Rocket Systems to one that mets the requirements of the Anti-Surface Warfare Master Plan. These rockets provide a high volume of air-to-ground fire from stand-off ranges against a broad target spectrum. The program was intended to maximize available RDT&E funds through the use of currently ongoing or planned Product Improvement Programs, NDI and FWE/NCT candidate components. The motor were intended to have a minimum effective range of 10,000 meters direct fire and 15,000 meters loft delivery is required. Warhead were to include Color marking; anti-personnel, material, armor, helicopter and coastal shipping; chaff; flare; smoke screening; night marking; and training.

The HYDRA XXI will be an improvement of the HYDRA-70 2.75 Inch Rocket System which is currently in production/deployment phase. The objective is to upgrade the 2.75 Inch Rocket system with and infusion of information age digital technology to fulfill its mission on the Force XXI/digitized battlefield of the 21st Century. This will be accomplished in the near term through Materiel Change upgrades of components(warheads, fuzes, rocket motor & launcher) to address emerging and changing requirements such as Insensitive Munitions, Hazards of Electromagnetic Radiation to Ordnance, environmental and other operational deficiencies that may develop as the system progresses in service. Other upgrades will include the evaluation and development of fuzes and warheads to meet new operational needs identified by the Army, Navy, Marine, Air Force, and Special Operation Forces such as employment in Military Operations in Urban Terrain. Additional applications are being pursued for the use of the system for light infantry and ground mobile forces. The improvement of the system is being managed by the Project Manager for the 2.75 inch rocket system located at the Industrial Operations Command at Rock Island IL, who has developed a Joint Service Improvement Plan which is a road map for the improvement of the rocket system.

The Army's Advanced Precision Kill Weapon System (APKWS) is intended to fill the gap between the current unguided 2.75" Hydra-70 Rocket System and the HELLFIRE anti-tank missile. It is anticipated that APKWS will be comprised of a laser sensor and guidance package coupled with the Hydra-70 rocket. It is designed to use the current MK66 rocket motor, M151 10 pound high explosive fragmentation warhead, M423 point detonating fuse, and the M260 or M261 rocket launcher. The MK66 rocket motor and associated component parts (warhead, fuze, etc.) are those that are currently in the inventory, however, the APKWS is designed to be compatible with any 2.75 inch rocket system in the inventory at time of acquisition. The rocket warhead and fuze are integrated with a laser sensor and a highly accurate guidance assembly resulting in a precision

guided weapon. The APKWS is programmed with the aircraft's compatible laser code and loaded into the aircraft rocket launcher(s). The APKWS is designed and intended to enhance the existing rocket system and to complement the Hellfire missile system; providing a significantly lower cost per kill against soft to lightly armored point targets. Precision guidance and warhead size of the APKWS will significantly reduce collateral damage. These features will make APKWS the weapon of choice during operations in urban terrain or for aerial fire support missions in close proximity to friendly forces. The APKWS will be employed from attack, armed reconnaissance, or other designated helicopters.

While operation is expected to be much the same as with HELLFIRE (using laser designation of the target); the smaller warhead, less complex seeker, and utilization of the Hydra-70 rocket will allow precision engagement of soft to lightly-armored targets at significantly lower costs than with HELLFIRE. The APKWS study is an effort to evaluate the cost-benefit of modifying the 2.75-inch unguided rocket with a laser sensor to increase the number of "stored" kills per attack/scout helicopter. The methodology considers the type threat units likely to be encountered in various locations of the world, the number of candidate targets for the APKWS, the potential combat effectiveness of an Aviation Restructure Inititive (ARI) interim attack battalion, and the potential for cost savings to attrit the threat units to two different levels. The study also evaluates the impact of collateral damage control and logistics.

APKWS will provide Army aviation with a low cost, highly accurate weapon for engagement of light-armored and soft point targets. It offers high single shot probability of hit against medium to long range point targets (1 km to >6 kms). The weapon will enhance aviation’s capability and lethality in all roles, especially MOUT, early entry, and aerial fire support missions. Current plans, funding permitting, call for fielding of APKWS in FY 02.

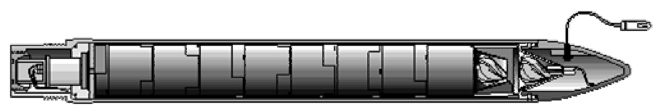
Documents

- FM 101-50-27-2 JMEM, Air-to-Surface, "Helicopter Deliveries (Materiel)", Revision 2, 12 Oct 1990. Classification: SECRET. Distribution authorized to U.S. Government agencies only. Other requests for this document must be referred to Director, AMSAA, Attn: AMXSY-J, Aberdeen Proving Ground, MD 21005-5071. This document contains tables of probability of kill (M, M/F, F, M/P) as a function of volley size, altitude, slant range, and airspeed against armored vehicles (T-62, BMP-1, BTR-60pB, T-80+, ZSU-23-4) for AH-64, AH-1F and "Simple" fire control firing the M151 and M261 warhead.
- FM 101-50-27-1 JMEM, Air-to-Surface, "Helicopter Deliveries (Personnel)", 2 Oct 1975. Classification: CONFIDENTIAL. Distribution authorized to U.S. Government agencies only. Other requests for this document must be referred to Director, AMSAA, Attn: AMXSY-J, Aberdeen Proving Ground, MD 21005-5071. This document contains tables of fractional coverage of personnel (standing, prone, and fox-hole)

area targets (10x10m, 50x50m, 100x100m, 300x300m targets) for the M151 as a function of total system error, altitude, ground range, and airspeed.

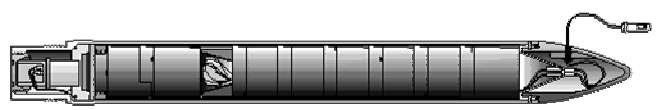
- FM 101-50-20 JMEM, Air-to-Surface, "Weapon Characteristics (JMEM)", 1 Apr 1995. Classification: SECRET. Distribution authorized to U.S. Government agencies only. Other requests for this document must be referred to Director, AMSAA, Attn: AMXSY-J, Aberdeen Proving Ground, MD 21005-5071. This document contains static fragmentation data for the M151 and M261 warheads. It also contains penetration data of the M73 submunition (profile hole diameter as function of standoff and penetration).
- FM 101-50-1 JMEM, Air-to-Surface, "Weapon Effectiveness, Selection, and Requirements (Basic JMEM A/S)", 31 Jan 1995. Classification: CONFIDENTIAL. This document contains lethal areas as a function of angle-of-fall for personnel, armored (light and heavy), artillery, parked aircraft, land transportation (trucks and locomotives), radar installations, communication antennas and jammers, missile sites, and industrial targets for the M151 warhead.

M151 High-Explosive

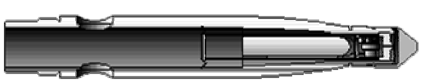


M261 High-Explosive Submunition

M156 White Phosphorus (Smoke)

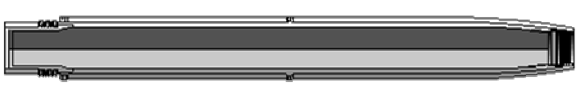


M267 Smoke Signature Submunition

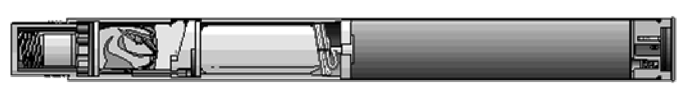


M274 Smoke Signature (Training)

4A/A WDU Flechette

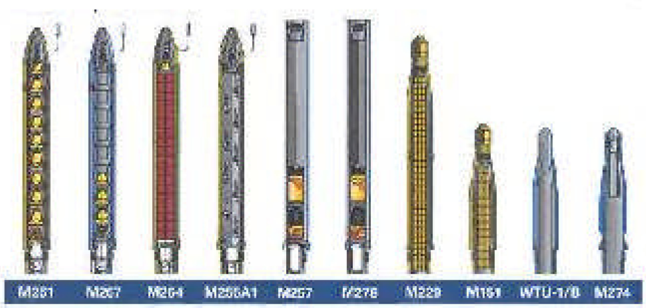


M229 High-Explosive



M257 Illumination

HYDRA 70 ROCKET SYSTEM FAMILY



Zuni 5.0-Inch [130 mm] Rocket

The unguided Zuni 5.0-Inch [130 mm] Rocket was originally developed for both air-to-air and air-to-ground applications, but is currently used almost exclusively in the later role. The rockets can also be used to illuminate and mark ground targets, and deliver chaff countermeasure systems. The rockets are assembled into complete all-up-rounds to deliver a variety of payloads. The type of fuze and warhead combination is determined by the tactical requirement.

The Zuni unguided rocket uses folding fins for aerodynamic stability. The 26.7 kilogram Mk-16 Mod 3 motor incorporates a double-base solid propellant with a burn time of 1.2 to 1.5 seconds, depending on ambient temperature. The motor is is 1.95 m long with a diameter of 130 mm. In the early 1970s a PIP was conducted to develop and qualify a 5.0 inch rocket motor with improved accuracy and performance. DT of the Mk-71 Mod 1 was completed and a release for production was granted in February 1973. Operational Test (OT) was conducted in 1972-73. Full production of the Mk-71 Mod 1 motor began in September 1973. The rocket motor Mk 71 Mod 1 consists of a motor tube and contact band assembly, the igniter, the stabilizing rod assembly, the charge support spring, spacer and cup assembly, the propellant grain assembly, the seal ring, the nozzle and fin assembly, the radiation hazard barrier and shielding band. The Mk 71 Mod 1 motor is classified as “HERO safe ordnance” when the radiation hazard barrier and shielding band are in place.

The warhead is delivered without the fuze installed. The fuze and warhead combination is determined by mission need. Overall rocket length and weight will vary dependent on fuzed warhead combination. Standard warheads include the Mk 24 GP explosive warhead that is 0.48 m long, has a diameter of 133 mm and weighs 22 kg, and the Mk 32 shaped charge warhead for anti-armour targets that is 0.76 m long, has a diameter of 133 mm and weighs 20 kg. On 14 January 1969 a fire aboard Enterprise resulting from detonation of a MK-32 Zuni rocket warhead overheated by exhaust from an aircraft starting unit, took 27 lives, injured 344 and destroyed 15 aircraft.

The rockets are fired from the all weather LAU-10 launcher, which can be used at speeds up to Mach 1.2. The 5.0 Inch Rocket launchers are a cylindrical construction of four aluminum launch tubes. These launch tubes are held together with metal ribs and are covered by an aluminum skin. Launchers can be fitted with forward and aft frangible fairings depending on overall rocket length and fuzing for airborne configuration. The launcher has a frangible nose and tail fairings which disintegrate on firing, and the rockets can be fired singly or in ripple mode. The 5.0 Inch Rocket System uses the four round LAU-10C/A (shore-based use only) and LAU-10D/A (shore-based or shipboard use) rocket launchers. The difference between the LAU-10C/A and LAU-10D/A reusable rocket launchers is the external thermal coating on the LAU-10D/A that greatly prolongs cook-off protection time. Full production of these launchers began in September 1973.

Aircraft rockets were China Lake's raison d'etre at its establishment. The early forward-firing aircraft rockets developed by the CalTech-NOTS team included the 5.0-Inch Aircraft Rockets and the 5.0-Inch High-Velocity Aircraft Rocket [HVAR] "Holy Moses" which remained in the Fleet until the mid-1960s. Folding-fin aircraft rockets (FFARs) are another highly successful China Lake product, with literally millions of the 5.0-inch Zuni

having been fired in combat. This rocket has been built under licence in Belgium by Forges de Zeebrugge (now a subsidiary of Thomson Brandt) since 1966. There have been no recent improvements to the 5.0 Inch Rocket.

Variants

PAYLOAD	WARHEAD	FUZE
HE Fragmentation	Mk 63 Mod 0	• Mk 93 Mod 0 with Ballistic Booster Unit (BBU)-15/B Booster Adapter • Mk 352 Mod 2 with Ballistic Booster Unit (BBU)-15/B Booster Adapter, • Fuze Mechanical Unit (FMU)-90/B with BBU-15/B Booster Adapter.
HE General Purpose	Mk 24 Mod 0,1	• Mk 93 Mod 0 with BBU-15/B Booster Adapter • Mk 188 Mod 0 with BBU-15/B Booster Adapter • Mk 352 Mod 2 with BBU-15/B Booster Adapter • FMU-90/B with BBU-15/B Booster Adapter and permanently installed Mk 191 Mod 0 Base Fuze
Anti Tank/Anti Personnel	Mk 32 Mod 0	• Mk 93 Mod 0 with BBU-15/B Booster Adapter • Mk 188 Mod 0 with BBU-15/B Booster Adapter • Mk 352 Mod 2 with BBU-15/B Booster Adapter • FMU-90/B with BBU-15/B Booster Adapter.
Flare (Illumination)	Mk 33 Mod 1	Permanently installed Mk 193 Mod 0 Fuze.
Smoke WP	Mk 34 Mod 0	• Mk 93 Mod 0 with Special Adapter, • Mk 188 Mod 0 with BBU-15/B Booster Adapter • Mk 352 Mod 2 with BBU-15/B Booster Adapter • FMU-90/B with BBU-15/B Booster Adapter
Smoke RP	Mk 34 Mod 2	• Mk 188 Mod 0 BBU-15/B Booster Adapter

		• Mk 352 Mod 2 with BBU-15/B Booster Adapter
Chaff/Countermeasure	Mk 84 Mod 4 RR-182/AL	• FMU-136/B (Permanently Installed) • FMU-136/B (Permanently Installed)
Practice	Mk 6 Mod 7 Mk 24 Mod 0 Mk 32 Mod 0	Solid steel nose ogive or Nose Plug.

AGM-12 Bullpup

The AGM-12 Bullpup command-guided missile was the first mass-produced air-to-surface guided missile. The disappointing Korean bridge-bombing experience stimulated the Navy to pursue development of the postwar Bullpup program.
The ASM-N-7 Bullpup was first deployed overseas in April 1959 when VA-212, equipped with FJ-4B Furies, sailed from Alameda on board Lexington to join the Seventh Fleet in the western Pacific. The following August, VA-34, equipped with A4Ds sailed from the east coast abroad the Saratoga to join the Sixth Fleet, thus extending Bullpup deployment to the Mediterranean.
The original ASM-N-7 Bullpup was soon upgraded to an improved variant, the ASM-N-7A, in 1960, which was redesignated AGM-12B Bullpup-A in 1962. The AGM-12B was put into second source production by W.L. Maxson. Production terminated in 1970 at 22,100 rounds.
The AGM-12C Bullpup B was a larger follow-on version of the original Bullpup air-to-surface radio-guided missile. The AGM-12C carried a 1,000 pound semi-armor-piercing warhead in the enlarged midsection. The largest of the Bullpup series of missiles, the AGM-12C is also the oddest-looking member, distinguished from the other Bullpup versions by its unusual long-chord wings. It weighed 1,785 pounds and used a 30,000-pound thrust liquid-fuel rocket engine to achieve a range of ten miles. The pilot guided the missile by watching the position of tail-mounted tracking flares in relation to his line-of-sight view of the target. Steering commands to correct the missile flight path were sent via one of the 24 available radio channels.
The Bullpup B entered USAF service in 1965, and was carried by F-4 and F-105 fighters during the Vietnam war. Its small warhead, however, was totally inadequate against North Vietnamese bridges. The Navy's Walleye proved better.

The AGM-12D was a nuclear variant originally known as the GAM-83B, but redesignated the AGM-12D. This variant looked much like the AGM-12B, but had a slightly larger diameter that allowed it to carry either a conventional or tactical nuclear warhead.

The AGM-12E had a cluster bomb warhead intended for use against anti-aircraft sites, but only about 840 were built.
More than 4,600 AGM-12Cs and 800 AGM-12Es were built. They were withdrawn from USAF service in the mid-1970s. Foreign users included the Royal Navy and various NATO forces. Some Bullpups are still in service, usually in ground attack training programs.
AGM-83 Bulldog was a laser-guided version of Bullpup that was never produced.

Specifications

Manufacturer	Lockheed Martin
Weight	1,785 lbs.
Length	13.6 ft.
Diameter	18 inches
Wingspan	48 in.
Guidance:	
Propulsion	Storable, liquid-fuel rocket
Speed	approx. Mach 1.8
Range	10 nm
Warhead	970 lbs conventional high-explosive

AGM-45 Shrike

The AGM-45 SHRIKE series weapon system is a passive air-to-ground missile whose mission is to home on and destroy or suppress radiating radar transmitters, directing both ground antiaircraft fire and surface-to-air missiles. The system consists of an AGM-45 guided missile, AERO-5A/B or LAU-118 launcher, and a launch aircraft configured with SHRIKE-unique avionics and a target identification acquisition system. The AGM-45 SHRIKE guided missile is composed of four major sections; guidance, warhead, control, and rocket motor. Along with the wing and fin assemblies, the sections make up the all-up-round missile. Several missile versions have been developed and produced to home on certain types of enemy radar transmitters. Each version consists of a guidance section specially developed and tuned to a specific frequency range unique to an individual threat radar. The AERO-5B-1 and LAU-118 series rail launchers are used to launch the SHRIKE missile. They provide the electrical and mechanical interface between the SHRIKE guided missile and the launch aircraft.

NOTS developed Shrike, the first successful antiradar missile, beginning in 1958 as a direct response to Fleet needs, and China Lake personnel took the missile to the carriers in Southeast Asia in the 1960s. During the Vietnam War, aircraft launched the first combat firing of the Shrike. Shrike was developed following many of the same principles that guided Sidewinder development: simplicity, reliability, maintainability, producibility, improvability. The AGM-45 was the first mass produced missile built specifically for the anti-radar mission, and more than 20,000 Shrikes were produced beginning in 1962. The Shrike's effectiveness was limited by the requirement that the missile be pointed at the intended target radar during launch, and that the Shrike will lose its lock if the radar ceases to radiate. The Shrike is now being replaced by the much improved AGM-88 HARM.

Specifications

Manufacturer	Texas Instruments, Sperry Rand/Univac
Weight	390 lbs.
Length	10 ft.
Diameter	8 inches
Wingspan	3 ft.
Guidance: Radar-homing	
Propulsion	Rocketdyne Mk 39 or Aerojet Mk 53 polybutadiene solid-fuel rocket
Speed	approx. Mach 2

Range	approx. 10 mi for AGM-45A up to 28.8 mi for AGM-45B with improved rocket motor
Warhead	145 lbs conventional high-explosive/fragmentation





AGM-62 Walleye II

The AGM-62 WALLEYE is a guided glide bomb designed to be delivered on a surface target from an attack aircraft. It is used primarily against targets such as fuel tanks, tunnels, bridges, radar sites, port facilities, and ammunition depots. The weapon system consists of the weapon, the attack aircraft, the AN/AWW-9B data link pod, and the OK-293/AWW control group. The WALLEYE is unique in that it has no propulsion section and must rely on its ability to glide to the target after release from the aircraft.

There are three basic series of the WALLEYE weapon. The original WALLEYE I Extended Range Data Link (ERDL) utilizes a tone data link system while the newer version utilizes the differential phase shift keyed digital data link, designed to prevent signal jamming. The WALLEYE II and WALLEYE II ERDL are greater in diameter, length, and weight than the WALLEYE I ERDL weapons. The AGM- 62 designation for Walleye nomenclature is not in wide use.

China Lake designed and developed the first precision-guided antisurface weapon, the Walleye (AGM-62) TV-guided glide bomb. Related to Walleye but cancelled before completion was Condor (AGM-53), a rocket-powered TV-guided missile. Extended-range data links have also been developed for Walleye. China Lake also developed Bulldog (AGM-83), the first successful laser-guided missile, which was approved for service use in 1974 but cancelled in favor of the Air Force Maverick.

In January 1963 a Walleye television glide bomb, released from a YA-4B, made a direct impact on its target at the Naval Ordnance Test Station, China Lake in the first demonstration of its automatic homing feature. A contract for production of the Walleye television homing glide bomb was issued to the Martin Marietta Corporation in January 1966. An outgrowth of in-house China Lake technology efforts, Walleye was fielded in 1967 and proved its unsurpassed accuracy in combat.

Originally developed by the Navy, the Air Force began Walleye combat tests in Vietnam during August 1967 that achieved excellent results in good visibility against targets that gave a strong contrast and were lightly defended. Later Walleye operations in more demanding conditions were less successful. It continued to be used in Southeast Asia, but due to its operating restrictions, cost, and the appearance of laser-guided bombs (LGB), comprised only a small fraction (6 percent) of the total number of PGMs employed in Vietnam.

The ERDL weapon provides distinct advantages over the standard WALLEYE. With the ERDL version, the added data link permits the weapon to continue to send a video target display from launch of the weapon until target impact. The data link further allows the controlling aircraft to control the weapon in flight and to either retarget or redefine the target aim point. The controlling aircraft can be the launching aircraft or a second aircraft equipped with a data link pod (AN/AWW-9B).

The 1427-1435 MHz band is used for proficiency training using various guided weapon systems. The weapon systems and supporting data links that operate in this band include the AWW-13 Advanced Data Link, used in the Walleye and SLAM. The current Navy inventory includes approximately 200 Walleye and 800 SLAM weapon systems. The loss of this band for missile command operations would render Navy systems more susceptible to jamming and will impair their terminal guidance. Compounding the problem are developmental weapons, such as the Joint Standoff Weapon Unitary (JSOW Unitary), that will use the AWW-13. The AWW-13 requires spectrum for both command and video functions.

Electro-optical [EO] sensors such as used on Walleye depend on both light and optical contrast for target searching and identification. This obviates their use at night and in significantly adverse weather or visual conditions where the line of sight to a target was obscured. The requirement for visual contrast between the target and its immediate surroundings imposed problems during Desert Storm. For Walleye delivery, F/A-18 pilots reported that a target was sometimes indistinguishable from its own shadow. This made it difficult to reliably designate the actual target, rather than its shadow, for a true weapon hit. The the low-light conditions at dawn and dusk often provided insufficient light for the required degree of optical contrast. A "haze penetrator" version of Walleye used low-light optics to see through daytime haze and at dawn and dusk, permitting use in some of the conditions in which other optical systems were limited.

The SLAM is based on the highly successful and reliable Harpoon anti-ship missile, with a Global Positioning System-aided Inertial Navigation System (GPS/INS) for mid-course guidance, and a Maverick imaging infrared sensor and a Walleye data link for precise, “man-in-the-loop” terminal guidance.

AGM-65 Maverick

The AGM-65 Maverick is a tactical, air-to-surface guided missile designed for close air support, interdiction and defense suppression mission. It provides stand-off capability and high probability of strike against a wide range of tactical targets, including armor, air defenses, ships, transportation equipment and fuel storage facilities. Maverick was used during Operation Desert Storm and, according to the Air Force, hit 85 percent of its targets.

The Maverick has a cylindrical body, and either a rounded glass nose for electro-optical imaging, or a zinc sulfide nose for imaging infrared. It has long-chord delta wings and tail control surfaces mounted close to the trailing edge of the wing of the aircraft using it. The warhead is in the missile's center section. A cone-shaped warhead, one of two types carried by the Maverick missile, is fired by a contact fuse in the nose. The other is a delayed-fuse penetrator, a heavyweight warhead that penetrates the target with its kinetic energy before firing. The latter is very effective against large, hard targets. The propulsion system for both types is a solid-rocket motor behind the warhead.

A-10, F-15E and F-16 aircraft carry Mavericks. Since as many as six Mavericks can be carried by an aircraft, usually in three round, underwing clusters, the pilot can engage several targets on one mission. The missile also has "launch-and-leave" capability that enables a pilot to fire it and immediately take evasive action or attack another target as the missile guides itself to the target. Mavericks can be launched from high altitudes to tree-top level and can hit targets ranging from a distance of a few thousand feet to 13 nautical miles at medium altitude.

The Maverick variants include electro-optical/television (A and B), imaging infrared (D, F, and G), or laser guidance (E). The Air Force developed the Maverick, and the Navy procured the imaging infrared and the laser guided versions. The AGM-65 has two types of warheads, one with a contact fuse in the nose, the other a heavyweight warhead with a delayed fuse, which penetrates the target with its kinetic energy before firing. The latter is very effective against large, hard targets. The propulsion system for both types is a solid-rocket motor behind the warhead.

Maverick A has an electro-optical television guidance system. After the protective dome cover is automatically removed from the nose of the missile and its video circuitry activated, the scene viewed by the guidance system appears on a cockpit television screen. The pilot selects the target, centers cross hairs on it, locks on, then launches the missile.

The **Maverick B** is similar to the A model, although the television guidance system has a screen magnification capability that enables the pilot to identify and lock on smaller and more distant targets.

The **Maverick D** has an imaging infrared guidance system, operated much like that of the A and B models, except that infrared video overcomes the daylight-only, adverse weather limitations of the other systems. The infrared Maverick D can track heat generated by a target and provide the pilot a pictorial display of the target during darkness and hazy or inclement weather.

The **Maverick E** is being adopted in the AGM-65E version as the Marine corps laser Maverick weapon for use from Marine aircraft for use against fortified ground installations, armored vehicles and surface combatants. Used in conjunction with ground or airborne laser designators, the missile seeker, searches a sector 7 miles across and over 10 miles ahead. If the missile loses laser spot it goes ballistic and flies up and over target -- the warhead does not explode, but becomes a dud.

The **Maverick F** AGM-65F (infrared targeting) used by the Navy has a larger (300 pound; 136 kg) penetrating warhead vice the 125 pound (57 kg) shaped charge used by Marine and Air Force) and infrared guidance system optimized for ship tracking.

The **Maverick G** model essentially has the same guidance system as the D, with some software modifications that track larger targets. The G model's major difference is its heavyweight penetrator warhead, while Maverick A, B and D models employ the shaped-charge warhead.

The Air Force accepted the first AGM-65A Maverick in August 1972. A total of 25,750 A and B Mavericks have been purchased by the Air Force. The Air Force took delivery of the first AGM-65D in October 1983, with initial operational capability in February 1986. Delivery of operational AGM-65G missiles took place in 1989. AGM-65 missiles were employed by F-16s and A-10s in 1991 to attack armored targets in the Persian Gulf during Operation Desert Storm. Mavericks played a large part in the destruction of Iraq's significant military force.

TV Mavericks have been experiencing declining reliability and maintainability since exceeding their 10 year shelf life over 10 years ago. The Depot purchased a lifetime buy of all spare parts for TV Mavericks in FY88 and those parts are running out. Due to funding shortfalls, the Depot has ceased to repair AGM-65A Maverick missiles and concentrates on maintaining AGM-65B, AGM-65D, and AGM-65G Maverick missiles.

AGM-65K

The U.S. Air Force and Raytheon have worked out an intricate arrangement to upgrade electro-optically-guided AGM-65 air-to-ground Maverick missiles through reuse of hardware on older Mavericks. The upgrade is intended to extend the service life of the AGM-65 through the use of a charge coupled device (CCD) seeker. Operational benefits of the CCD include greater reliability and the ability to operate in lower light levels.

The AF put together a plan to buy about 2,500 missiles but was unable to fund the program. As a result, it scaled back its procurement plans to about 1,200. Also, Raytheon

proposed an exchange program in which it reuses parts of older Mavericks to reduce the cost of the improved Mavericks. The two-part agreement calls for Raytheon to buy old missiles and guidance and control sections from the AF.

The main portion of the program calls for Raytheon to buy back guidance and control sections of some of the 5,300 IR-guided AGM-65Gs the AF bought after the 1991 Persian Gulf War. The IR seekers have six cards that are common with the CCD and are reused. The CCDs then are mated with the center aft section of the missiles that were earlier stripped of their IR seeker. The new missile will be known as the AGM-65K.

The AF first considered a CCD upgrade using AGM-65Bs to make AGM-65Hs. Those missiles have a 125-pound warhead. But the conversion program taking AGM-65Gs - which have a more powerful 300-pound warhead - and making them into AGM-65Ks will be lower cost. Raytheon will use IR seeker parts not needed by the CCD for foreign military sales customers. Although some of the IR seeker would have to be newly built, the reuse of some hardware will make the total seeker less expensive than it would have been otherwise.

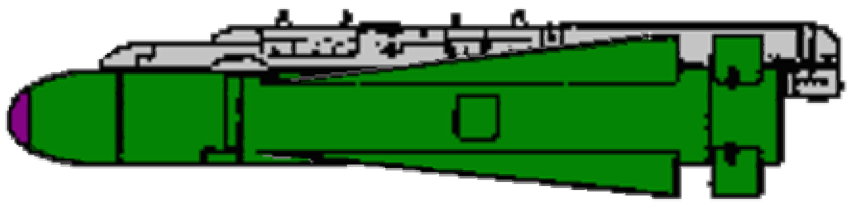
The second part of the AGM-65K program involves Raytheon's procurement of up to 1,000 of about 7,000 AGM-65As that have been in cold storage. This became necessary because Raytheon's Maverick airframe supplier was getting out of the business, even though Raytheon still receives foreign orders for new missiles.
After detailed analysis and disassembly of six missiles, the cold storage AGM-65As were deemed to be as good as the day they were built. The missiles are corrosion coated inside and out, and not just on the outside like newer Mavericks. The arrangement calls for the US Government to receive about $2,150 per missile. Raytheon takes the missile apart and returns those items that need to be demilitarized, such as the warhead, to the government. The government pays disposal costs which would have been incurred anyway. Because Raytheon disassembles the missile, the government saves about $500 to $1,000 per unit. The approximately $2.1 million the government will receive will go towards the AGM-65 upgrade.
One of the advantages for foreign military sales customers is stable pricing for the airframe. In the past a small Maverick order could result in high airframe costs. That will no longer be the case. Only pristine missiles are being accepted. Raytheon is refusing any missiles that have been out of cold storage, such as captive-carry missiles. Some consideration is even being given to reuse some parts of the AGM-65A. In addition to its combat missiles the AF will also receive upgraded training missiles. Although the Raytheon/AF agreement allows the AF to move forward with the CCD upgrade, the scope of the program is much smaller than first planned. The AF was hoping to upgrade about 2,500 missiles, about 50% of the requirement Air Combat Command has articulated.

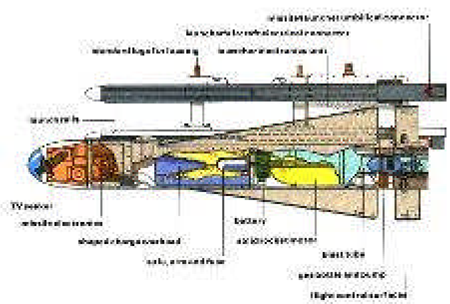
Specifications

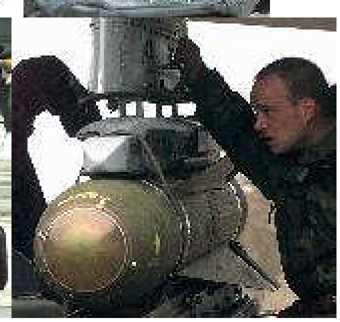
Primary Function:	Air-to-surface guided missile				
Contractors:	Hughes Aircraft Co., Raytheon Co.				
Power Plant:	Thiokol TX-481 solid-propellant rocket motor				
Autopilot	Proportional Navigation				
Stabilizer	Wings/Flippers				
Propulsion	Boost Sustain				
Variant	AGM-65A/B	AGM-65D	AGM-65G	AGM-65E	AGM-65F
Service	Air Force			Marine Corps	Navy
Launch Weight:	462 lbs (207.90 kg)	485 lbs (218.25 kg)	670 lbs (301.50 kg)	630 lbs (286 kg)	670 lbs (301.50 kg)
Diameter:	1 foot (30.48 centimeters)				
Wingspan:	2 feet, 4 inches (71.12 centimeters)				
Range:	17+ miles (12 nautical miles/27 km)				
Speed:	1150 km/h				
Guidance System:	electro-optical television	imaging infrared		Laser	infrared homing
Warhead:	125 pounds (56.25 kilograms) cone shaped		300 pounds (135 kilograms) delayed-fuse penetrator, heavyweight	125 pounds (56.25 kilograms) cone shaped	300 pounds (135 kilograms) delayed-fuse penetrator, heavyweight
Explosive	86 lbs. Comp B		80 lbs. PBX(AF)-108		
Fuse	Contact		FMU-135/B		

COSTS	Air Force AGM-65D/G	Navy AGM-65E/F
Development cost	$168 million	$25.5 million
Production cost	$2,895.5 million	$627.5 million
Total acquisition	$3,063.5 million	$653 million

Acquisition unit cost		$129,322		$158,688	
Production unit cost	$17,000	$122,230		$152,491	
Date Deployed:	August 1972	February 1986	1989		
Quantity	12,559	23,689		4,115	
Aircraft:	A-10, F-15E and F-16			F/A-18	F/A-18 and AV-8B









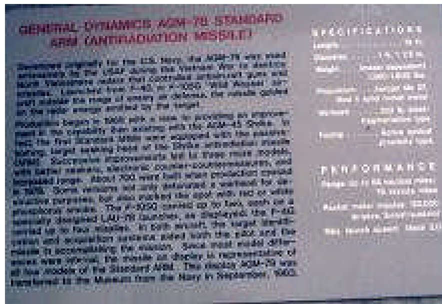

AGM-78 Standard ARM

Developed originally for the U.S. Navy, the AGM-78 was used extensively by the USAF during the Vietnam War to destroy North Vietnamese radars that controlled antiaircraft guns and missiles. Launched from F-4G or F-105G "Wild Weasel" aircraft outside the range of enemy radar defense, the missile guided on the radar energy emitted by the target. Production began in 1968 with a view to providing an improvement in the capability then existing with the AGM-45 Shrike. In fact, the first Standard ARMs were equipped with the passive homing, target seeking head of the Shrike antiradiation missile (ARM).

Successive improvements led to three more models, with better seekers, electronic counter-countermeasures, and increased range. About 700 were built when production ceased in 1978. Some versions not only detonated a warhead for destructive purposes, but also marked the spot with red or white phosphorus smoke. The F-105G carried up to two, each on a specially designed LAU-78 launcher; the F-4G carried up to 4 missiles. In both aircraft, the target identification and acquisition systems aided both the pilot and the missile in accomplishing the mission.

Specifications

Length	15 ft.
Diameter	1 ft. 1 1/2 in.
Weight	(model dependent) 1,350-1,800 lbs.
Propulsion	Aerojet Mk 27, Mod 4 solid rocket motor
Warhead	223 lb. blast-fragmentation type
Fusing	Active optical proximity type
Range	Up to 75 statute miles
Rocket motor impulse	120,000 lb.-secs. (boost-sustain)
Max. launch speed	Mach 2.0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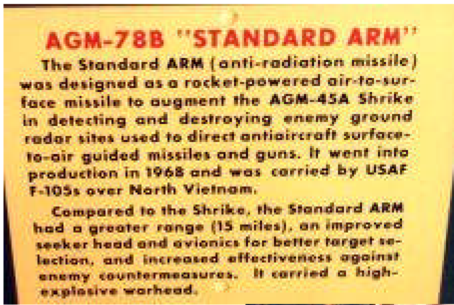
ARM (ANTIRADIATION MISSILE)
SPECIFICATIONS
PERFORMANCE


AGM-78B "STANDARD ARM"
The Standard ARM (anti-radiation missile) was designed as a rocket-powered air-to-surface missile to augment the AGM-45A Shrike in detecting and destroying enemy ground radar sites used to direct antiaircraft surface-to-air guided missiles and guns. It went into production in 1968 and was carried by USAF F-105s over North Vietnam.
Compared to the Shrike, the Standard ARM had a greater range (15 miles), an improved seeker head and avionics for better target selection, and increased effectiveness against enemy countermeasures. It carried a high-explosive warhead.

AGM-84 Harpoon
SLAM [Stand-Off Land Attack Missile]

The Harpoon missile provides the Navy and the Air Force with a common missile for air, ship, and submarine launches. The weapon system uses mid-course guidance with a radar seeker to attack surface ships. Its low-level, sea-skimming cruise trajectory, active radar guidance and warhead design assure high survivability and effectiveness. The Harpoon missile and its launch control equipment provide the warfighter capability to interdict ships at ranges well beyond those of other aircraft.

The Harpoon missile was designed to sink warships in an open-ocean environment. Other weapons (such as the Standard and Tomahawk missiles) can be used against ships, but Harpoon and Penguin are the only missiles used by the United States military with anti-ship warfare as the primary mission. Once targeting information is obtained and sent to the Harpoon missile, it is fired. Once fired, the missile flys to the target location, turns on its seeker, locates the target and strikes it without further action from the firing platform. This allows the firing platform to engage other threats instead of concentrating on one at a time.

An appropriately configured HARPOON can be launched from an AERO-65 bomb rack, AERO-7/A bomb rack, MK 6 canister, MK 7 shock resistant canister, MK 12 thickwall canister, MK 112 ASROC launcher, MK 8 and MK 116 TARTAR launcher, or submarine torpedo tube launcher.

Submarines fire a capsule containing the Harpoon from their torpedo tubes. When the capsule breaches the surface, the top is blown off and the missile is launched. Aircraft launched Harpoons do not require a Booster. Depending upon launch conditions, the Harpoon engine generally will not start until after the missile is dropped from the wing. This allows firing from higher altitudes and longer range flights.

The *Guidance Section* consists of an active radar seeker and radome, Missile Guidance Unit (MGU), radar altimeter and antennas, and power converter. The MGU consists of a three-axis attitude reference assembly (ARA) and a digital computer/power supply (DC/PS). Prior to launch, the DC/PS is initialized with data by the Command Launch System. After launch, the DC/PS uses the missile acceleration data from the ARA and altitude data from the radar altimeter to maintain the missile on the programmed flight profile. After seeker target acquisition, the DC/PS uses seeker data to guide the missile to the target.

The *Warhead Section* consists of a target-penetrating, load-carrying steel structure containing 215 pounds of high explosive (DESTEX) and a safe-and-arm/contact fuze assembly. The safe-and-arm/contact fuze assembly ensures the warhead will not explode until after the missile is launched. It is designed to explode the warhead after impacting the target. The warhead section can be replaced by an exercise section which transmits missile performance data for collection and analysis.

The *Sustainer Section* consists of a fuel tank with JP-10 fuel, air inlet duct, and a jet engine. This provides the thrust to power the missile during sustained flight. The Sustainer Section has four fixed fins which provide lift.
The *Control Section* consists of four electromechanical actuators which use signals from the Guidance Section to turn four fins which control missile motion.
The *Booster Section* consists of a solid fuel rocket and arming and firing device. Surface and submarine platforms use a booster to launch Harpoon and propel it to a speed at which sustained flight can be achieved. The Booster Section separates from the missile before sustained flight begins.
The submarine Harpoon is contained within a capsule and is called ENCAP for encapsulated. The ENCAP is the same size and general shape of a blunt nosed torpedo and is launched from submarine torpedo tubes. It has positive buoyancy (it floats), so when it is ejected from the submarine, it will rise to the surface, without power. The ENCAP consists of a nosecap, main body and afterbody. The missile is on shock isolator rails within the main body. The afterbody has fins which direct the ENCAP towards the surface at the proper angle for missile launch. Once the ENCAP breaches the surface, the nosecap is blown off by a small rocket and the missile is launched.

The Harpoon missile was developed in the early 1970s. Numerous upgrades have kept it at the forefront of missile capabilities, including the Block 1 introduced in 1978, and the Block 1B introduced in 1981. Today, the latest variant developed in 1982 called Block 1C is deployed by the United States military (Navy and Air Force) as well as US allies. New developments are constantly being evaluated. Although originally planned to be in use until 2015, there is no plan to develop a replacement by the USN. There are continuing, extensive efforts (testing and analysis) to ensure no detrimental effects of missile aging. With budget constraints projected into the future, Harpoon will be employed past 2015.

The **AGM-84D Harpoon** is an all-weather, over-the-horizon, anti-ship missile system produced by Boeing [formerly McDonnell Douglas]. The Harpoon's active radar guidance, warhead design, and low-level, sea-skimming cruise trajectory assure high survivability and effectiveness. The missile is capable of being launched from surface ships, submarines, or (without the booster) from aircraft. The AGM-84D was first introduced in 1977, and in 1979 an air-launched version was deployed on the Navy's P-3 Orion aircraft. Originally developed for the Navy to serve as its basic anti-ship missile for fleetwide use, the AGM-84D also has been adapted for use on the Air Force's B-52G bombers, which can carry from eight to 12 of the missiles.

The **AGM-84D Harpoon Block 1D** (with a larger fuel tank and reattack capability) was developed in 1991. With the reduced threat because of the break-up of the Soviet Union, this upgrade was shelved and never produced.

The **AGM-84E Harpoon/SLAM [Stand-Off Land Attack Missile] Block 1E** is an intermediate range weapon system designed to provide day, night and adverse weather precision strike capability against high value land targets and ships in port. In the late 1980s, a land-attack missile was needed. Rather than design one from scratch, the US

Navy took everything from Harpoon except the guidance and seeker sections, added a Global Positioning System receiver, a Walleye optical guidance system, and a Maverick data-link to create the Stand-off Land Attack Missile (SLAM). The AGM-84E uses an inertial navigation system with GPS, infrared terminal guidance, and is fitted with a Tomahawk warhead for better penetration. SLAM can be launched from land-based or aircraft carrier-based F/A-18 Hornet aircraft. It was employed successfully in Operation Desert Storm and UN relief operations in Bosnia prior to Operation Joint Endeavor.

The **SLAM-ER (Expanded Response) Block 1F**, a major upgrade to the SLAM missile that is currently in production, provides over twice the missile range, target penetration capability, and control range of SLAM. SLAM-ER has a greater range (150+ miles), a titanium warhead for increased penetration, and software improvements which allow the pilot to retarget the impact point of the missile during the terminal phase of attack (about the last five miles). In addition, many expansions are being made to improve performance, survivability, mission planning, and pilot (man-in-the-loop) interface. The SLAM-ER development contract was awarded to McDonnell Douglas Aerospace (Now BOEING) in February of 1995. SLAM-ER achieved its first flight in March of 1997. All Navy SLAM missiles are currently planned to be retrofitted to SLAM-ER configuration. About 500 SLAM missiles will be converted to the SLAM-ER configuration between FY 1997 and FY 2001.

The **SLAM-ATA (Automatic Target Acquisition) Block 1G**, a follow on enhancement to SLAM-ER with reattack capability and new seeker, is under development. SLAM-ERs equipped with ATA will match the seeker images of a target scene with an on-board reference image. This process will improve the missile's ability to strike targets in cluttered spaces, such as urban areas. It will also improve missile targeting capability in poor weather, counter measure protected environments, and better enable offset aimpoint targeting.

The **Harpoon Block II** is an upgrade program to improve the baseline capabilities to attack targets in congested littoral environments. The upgrade is based on the current Harpoon. Harpoon Block II will provide accurate long-range guidance for coastal, littoral and blue water ship targets by incorporating the low cost integrated Global Positioning System/Inertial Navigation System (GPS/INS) from the Joint Direct Attack Munitions (JDAM) program currently under development by Boeing. GPS antennae and software from Boeing's Standoff Land Attack Missile (SLAM) and SLAM Expanded Response (SLAM ER) will be integrated into the guidance section. The improved littoral capabilities will enable Harpoon Block II to impact a designated GPS target point. The existing 500 pound blast warhead will deliver lethal firepower against targets which include coastal anti-surface missile sites and ships in port. For the anti-ship mission, the GPS/INS provides improved missile guidance to the target area. The accurate navigation solution allows target ship discrimination from a nearby land mass using shoreline data provided by the launch platform. These Block II improvements will maintain Harpoon's high hit probability while offering a 90% improvement in the separation distance between the hostile threat and local shorelines. Harpoon Block II will be capable of deployment from all platforms which currently have the Harpoon Missile system by using existing

command and launch equipment. A growth path is envisioned for integration with the Vertical Launch System and modern integrated weapon control systems. With initiation of engineering and manufacturing development in 1998, initial operational capability for Block II will be available by 2001.

At the direction of Headquarters Strategic Air Command, the Harpoon Air Command and Launch Control Set was fully integrated into a fully operational B-52G from Mather AFB, Calif., in March 1983. Three successful live launches at the Naval Air Warfare Center, Point Mugu, Calif., led to the modification of a total of 30 B-52Gs with Harpoon launch control equipment, enough to provide two squadrons of Harpoon-capable B-52Gs by June 30, 1985. The 42nd Bombardment Wing, Loring Air Force Base, Maine, and the 43rd Bombardment Wing, Andersen Air Force Base, Guam, were first tasked to perform the Harpoon mission. Both wings refined tactics and doctrine to merge the long-range, heavy-payload capability of the B-52 with the proven reliability of this superior stand-off attack weapon.

After Loring AFB closed and the retirement of the last B-52G at Castle AFB, Calif., the Harpoon mission was moved to the 2nd Bomb Wing at Barksdale AFB, La. Four B-52H models were rapidly modified (as an interim measure) to accept Harpoon launch control equipment pending B-52H fleet modification. By 1997, all B-52H airframes were Harpoon capable, providing both the 5th Bomb Wing at Minot AFB, N.D., and the 2nd Bomb Wing at Barksdale, full squadron strength capability.

Following five successful flight tests and the completion of developmental tests, in early 1998 the US Navy approved the second low-rate initial production lot of the Boeing Standoff Land Attack Missile Expanded Response. The decision paved the way for Boeing to produce 22 SLAM ERs with an option for an additional 20. Interim flight clearance was granted by Commander Naval Air Systems Command for employment of SLAM ER AGM-84H missiles on F/A-18C/D aircraft in two configurations:

- Configuration I: Stations 1 and 9: AIM-9, CATM-9 with/without Alrite laser reflector, or ballasted ARDS pod, or empty LAU-7; Stations 2 and 8: AGM-84H. Stations 5 and 7: 330 gallon fuel tank or AWW-13 pod or empty pylon. Station 6: Missile well cover or LAU-116.
- Configuration II: Stations 1 and 9: AIM-9, CATM-9 with/without Alrite laser reflector, or ballasted EATS pod or ballasted ARDS pod, or empty LAU-7; Stations 2 and 8: AWW-13 or empty pylon; Stations 3 and 7: AGM-84H; Stations 4 and 6: Missile well cover or LAU-116; Station 5: 330 gallon fuel tank or AWW-13 pod or empty pylon.

The Navy has proposed replacing the joint program for JASSM with SLAM-ER, prior to completion of the current program definition and risk reduction phase for JASSM. However, the SLAM-ER development and procurement schedule may be excessively concurrent. On the basis of a single controlled flight test, the Navy made a low rate initial production decision that will result in the procurement of approximately 19 percent of the total planned buy of SLAM-ER before the completion of development and operational

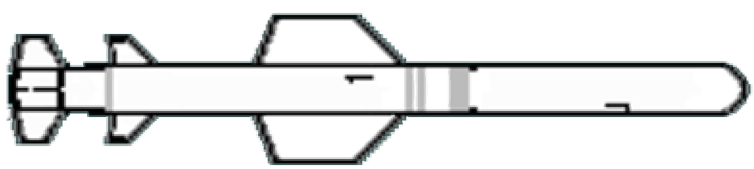
testing. And flight tests of a SLAM-ER with operational seeker will not be conducted until Development Test II.

The Harpoon missile launcher can be mounted on a truck. Another truck holds the Command Launch System electronics and a generator. Park the two trucks, connect them with cables, and the anti-ship missile battery is ready to control straits or prevent ships from threatening friendly soil.

Specifications

Primary Function:	Air-to-surface anti-ship missile			
Mission	Maritime ship attack			
Targets	Maritime surface			
Service	Navy and Air Force			
Contractor:	Boeing [ex McDonnell Douglas]			
Power Plant:	Teledyne Turbojet and solid propellant booster for surface and submarine launch			
Program status	Operational			
	sea-launch	air-launch	SLAM	SLAM-ER
First capability	1977	1979		
Thrust:	660 pounds			
Length:	15 feet (4.55 meters)	12 feet, 7 inches (3.79 meters)	14 feet, 8 inches (4.49 meters)	
Weight:	1,470 pounds (661.5 kilograms)	1,145 pounds (515.25 kilograms)	1,385 pounds (629.55 kilograms)	
Diameter:	13.5 inches (34.29 centimeters)			
Wingspan:	3 feet (91.44 centimeters)			
Range:	Greater than 60 nautical miles			150+ miles
Speed:	855 km/h			
Guidance System:	Sea-skimming cruise with mid-course guidance monitored by		inertial navigation system with GPS, infrared terminal guidance	

	radar altimeter, active seeker radar terminal homing	
Warheads:	Penetration high-explosive blast (488 pounds)	
Explosive	Destex	
Fuze	Contact	
Development cost	$320.7 million	
Production cost	$2,882.3 million	
Total acquisition cost	$3,203.0 million	
Acquisition unit cost	$527,416	
Production unit cost	$474,609	
Quantity	Navy: 5,983; Air Force: 90	
Platforms	A-6, F/A-18, S-3, P-3, B-52H, ships	









SLAMMER

AGM-88 HARM

The AGM-88 HARM (high-speed antiradiation missile) is a supersonic air-to-surface tactical missile designed to seek and destroy enemy radar-equipped air defense systems. The AGM-88 can detect, attack and destroy a target with minimum aircrew input. Guidance is provided through reception of signals emitted from a ground-based threat radar. It has the capability of discriminating a single target from a number of emitters in the environment. The proportional guidance system that homes in on enemy radar emissions has a fixed antenna and seeker head in the missile nose. A smokeless, solid-propellant, dual-thrust rocket motor propels the missile. The Navy and Marine Corps F/A-18 and EA-6B have the capability to employ the AGM-88. With the retirement of the F-4, the F-16C is the only aircraft in the current Air Force inventory to use the AGM-88. The B version has an improved guidance section which incorporates an improved tactical software and electronically reprogrammable memory.

The AGM-88 missile was approved for full production by the Defense Systems Acquisition Review Council in March 1983. The Air Force equipped the F-4G Wild Weasel with the AGM-88 to increase the F-4G's lethality in electronic combat. The missile worked with the APR-47 radar attack and warning system on the aircraft. The missile is operationally deployed throughout the Air Force and in full production as a joint US Air Force-US Navy project. HARM continues to prove its value against continuously emitting threat radar. Over 80 missiles were fired from USN/USMC aircraft both during and post Desert Fox.

The AGM-88A/B HARM is an evolution of anti-radiation missile weapon systems, SHRIKE and STANDARD ARM. HARM incorporates the more desirable features of each while providing additional capabilities that enhance operational effectiveness. Although generally similar in appearance and mission to the AGM-45 Shrike, produced more than 25 years prior to the AGM-88, the AGM-88 HARM is several feet longer than an AGM-45, has a slightly-enlarged diameter a foot back from the nose, and has a slightly greater diameter overall. The AGM-45 also has an RF window/slot on the side, not present on the AGM-88.

The system consists of the guided missile, LAU-118(V)1/A launcher, launch aircraft, and HARM peculiar avionics. The weapon system has the capability of detecting, acquiring, displaying, and selecting a radiating threat and launching a missile or missiles. The HARM Missile receives target parameters from the launch aircraft prior to launch. The HARM Missile uses these parameters and relevant attitude data to process incoming RF energy to acquire and guide the HARM Missile to the desired target. The HARM missile has a terminal homing capability that provides a launch and leave capability for the launch aircraft. Additional unique features include the high speed, low smoke, rocket motor and seeker sensitivity that enable the missile to easily attack sidelobes and backlobes of an emitter.

The following provides functional descriptions for each section of the HARM Missile and significant enhancements.

Guidance Section. Several modifications have been made to the HARM Guidance section through hardware modifications and software upgrades.

Hardware Configurations. The AGM-88A was the first version of the missile to be produced. It incorporated a fuzable-link memory that required the guidance section to be returned to the manufacturer to change the Tactical software. The AGM-88B missile was developed in the mid 1980s and incorporated an electronically reprogrammable memory that allowed changing the missile software in the field. The AGM-88C missile is the latest version and incorporates several new design features and is also reprogrammable in the field.

Software Versions. Block I software was the original Tactical software used with the AGM-88A missile. Block II software provided guidance and fuzing improvements and was used in both AGM-88A missiles and AGM-88B missiles. In 1990 Block III software was installed in AGM-88B missiles to counter the capabilities of the advanced threats. All AGM-88C missiles contained Block IV software which is currently the latest version.

Warhead Section. The warhead section is designed to inflict sufficient damage on the target antenna and waveguide system to force an inoperative condition. It also ensures complete destruction of the HARM Missile guidance section.. The AGM-88A, and AGM-88B warhead section contains 25,000 pre-formed steel fragments, an explosive charge, a fuze, and a fuze booster. The AGM-88C utilizes an improved warhead section containing 12,845 tungsten fragments and an improved explosive charge which provides greater overall lethality.

Control Section. The control section of the HARM Missile is located aft of the warhead section. The control section contains wing actuators to steer the missile on a desired trajectory, missile captive and free flight electrical power supply equipment, attitude reference equipment, and the missile target detection device. An umbilical connector mounted on top of the control section provides electrical interface between the launch aircraft and the missile.

Rocket Motor Section. Thrust for the HARM Missile is developed by a dual thrust rocket motor utilizing a low smoke propellant. The section contains a manually operated safety-arming device, igniter, propellant grain, and a fixed nozzle. External components on the rocket motor section consist of fittings for the fins, launch lugs, and a detent rib.

Wings. The wings direct the course of the HARM Missile in flight by internally controlled actuators within the control section. Four wings are required per missile.

Fins. The BSU-60/B and BSU-60A/B fins are identical type fins except for a redesigned locking mechanism. They are interchangeable as sets. The fins provide aerodynamic stability of the HARM Missile during flight.

Antiradiation missiles have an unparalleled ability to home in on enemy emitters and disrupt or destroy the elements of an integrated air defense system (IADS). However, they are not classic precision-guided weapons, such as laser-guided munitions. On the contrary, ARMs cannot be steered and under certain conditions may not guide on the target that they were originally fired. Also, they do not have the ability to discern friend from foe. Therefore, the precision detection capability of the launching platform and its human operator in the loop are key elements ensuring weapon effectiveness and the prevention of fratricide. The translation of what the launching aircraft sees to what the ARM sees is paramount.

Several unique factors effect ARM employment. Most significant are the ambiguities in the radar frequency spectrum which cause friendly, enemy, and neutral radar emissions to appear similar. Ambiguities make accurate platform targeting and missile guidance difficult. These ambiguities will continue to worsen as the frequency spectrum becomes more dense and overcrowded. A limited amount of frequencies is suitable for radar operations, and as newer systems evolve, more emitters will overlap. In some instances, high target area activity in a dense emitter environment may cause cockpit task saturation and decrease targeting efficiency. Now previously defined enemy emitters from the Soviet era cannot be exclusively classified as such. Potential partners in multinational combined operations may employ such systems, causing use of the same weapon system on both sides of a conflict. For example, in Desert Storm, coalition forces and Iraq both used the SA-6 and Hawk weapon systems. As systems intermingle during changing world political conditions, it will become increasingly difficult to detect friendly, enemy, and neutral radar emitters.

Rules of engagement (ROE) compensate for some of the above problems. Restricting weapons firing until specific conditions are met reduces potential fratricide as well as avoids inefficient weapons employment. However, ROE must be optimized for all platforms in theater and take into account each system's capabilities and limitations. Each service employs ARMs with different objectives and philosophies. Individual service platforms can employ ARMs with varying degrees of accuracy. To improve integration during a joint campaign, each service must understand how the other executes ARM employment. Likewise, inaccurate targeting and fratricide is prevented by knowing how friendly ground and naval emitters operate. Joint planners must extensively coordinate all aspects of ARM employment during a SEAD campaign. Critical to planning is the transmission of friendly emitter order of battle information to the aircrews. Timely, accurate data, combined with appropriate ROE and knowledge of ambiguous theater systems, will overcome the obstacles presented by a dense frequency spectrum.

The CP-1001B/C HARM Command Launch Computer (CLC) is an electronics subsystem installed on the airframe to interface with the AGM-88 A/B/C HARM Missile. The CLC and associated software package are compatible with all AGM-88 A/B/C missiles. The CLC receives target data from the missile and onboard avionics, processes the data for display to the aircrew to the appropriate display, determines target priority, and collects aircraft data for pre-launch hand-off to the AGM-88 HARM missile. The CLC determines time coincidence between the AGM-88 HARM missile and the RWR

directional data and pulse repetition intervals and formats. The identification data is processed by the CLC to perform target identification, prioritization, and display information. The CLC generates targeting commands to the AGM-88 HARM missile for appropriate target and provides Targeting and guidance information for the AGM-88 to Target Of Interest (TOI) on offensive attack missions.

The primary lethal Supression of Enemy Air Defense [SEAD] platform, the F-16 employing AGM-88 High Speed Anti-radiation Missiles (HARM) has several shortfalls. It is becoming increasingly difficult to logistically support the F-16 and the HARM. SEAD forces have limited automated mission planning capability. It is very difficult to stimulate, decoy, and saturate enemy threat radars without putting friendly forces in harm's way, and the ability to reactively target surface-to-air threats is limited. The ability to employ off-board targeting sources is limited in the timeliness and accuracy required for the preemptive destruction mission. Though offboard sources may find mobile targets, there is a limited capability to pass required information in real time so fighters can reactively or preemptively target mobile surface-to-air threats. There is no on-board capability to preemptively target mobile surface-to-air threat systems. Current SEAD weapons all depend on RF homing for guidance and are vulnerable to emission control (EMCON) countertactics. There is also limited capability to perform real-time battle damage assessment (BDA). On the non-lethal side, there is limited capability to suppress RF threats and C2 systems.

Upgrades

New systems and/or improvements to existing systems are required to ensure successful accomplishment of the lethal SEAD mission. In the near term, an upgrade to Harm Targeting System (HTS) will be fielded in 1999. Eventual augmentation or replacement of the HTS with an improved emitter targeting and passive identification system will provide expanded frequency coverage, more precise target location information and unambiguous emitter identification capability. Multi-ship targeting will provide great improvements in targeting accuracy and timeliness. It will require data link capability for real-time targeting of both reactive and preemptive target sets.

For the future, CINCS are demanding reliable, one-shot hard kills against threat radar, even if the radar shuts down prior to missile impact. The Navy has a three-step program to develop this capability for HARM.

1. HARM Block 3a and 5 software updates have completed testing and were incorporated as a software only engineering change starting in August 1999. The software improves missile performance against several threat countermeasures. The Block V software upgrade was fielded in 1999 and incorporates tighter control of missile flight path to reduce the risk of fratricide and increase kill probability. AGM-88C Block 5 missiles also feature a lethal capability against high power GPS jammers showcased in fleet battle experiments. To ensure continued EA-6B compatibility, OFP's SSA 5.2 and 89A 1.0 have been developed by the Weapons System Support Activity, Point Mugu, California. Both are

baselined from 5.1 COD, will include HARM III/IIIA/IV/V, and are supported by the same TEAMS release. Two successful live fires of IIIA and V missiles from Block 89A aircraft were made in September 1998 and were followed by Block 82/89 live fires. The differences in the OFP software is nearly transparent to the fleet. The 89A 1.0 OFP has been optimized for the Block 89A avionics architecture that includes a second 1553 navigation bus and CDNU bus control.

2. The international HARM upgrade program (AGM-88D Block 6 is the US designation) is a cooperative software and hardware upgrade. It will incorporate a current state of the art GPS/IMU in place of the original mechanical gyros to improve missile precision, increase kill probability, and further reduce the probability of fratricide. As a by-product, the missile will have a high-speed, point-to-point capability. Plans call for retrofit kit production in 2003.
3. The Advanced Anti-Radiation Guided Missile (AARGM) project is adding to the Block VI capability by demonstrating technology for RF homing integration with an active millimeter wave terminal seeker to provide a counter-shutdown capability. Fielding this capability could be in the 2005 timeframe.

Specifications

Primary Function:	Air-to-surface anti-radiation missile
Mission	Defense suppression
Targets	Fixed soft
Service	Navy and Air Force
Contractor:	Raytheon [Texas Instruments]
Program status	Operational
Date Deployed:	1984
Power Plant:	Thiokol dual-thrust rocket motor
Thrust:	Dual thrust
Length:	13 feet, 8 inches (4.14 meters)
Launch Weight:	800 pounds (360 kilograms)
Diameter:	10 inches (25.40 centimeters)
Wingspan:	3 feet, 8 inches (101.60 centimeters)
Range:	30 plus miles (48 plus kilometers)
Speed:	Max. speed: 2280 km/h
Guidance System:	Proportional
Guidance method	Homes on electronic emissions
Warhead	WAU-7/B, 143.51bs. Direct Fragmentation

Explosive (NEW)	PBXC-116 (45.2 lbs.)
Fuze	Pulsed Laser Proximity/Contact
Propulsion	Boost Sustain 64,000 lbs./sec. Low Smoke
Development cost	$644.5 million
Production cost	$5,568.1 million
Total acquisition cost	$6,212.6 million
Acquisition unit cost	$316,856
Production unit cost	$283,985
Quantity	19,607 (Navy and Air Force)
Platforms	F/A-18, F-4G, F-16






AGM-114 Hellfire

The Hellfire Air-to-Ground Missile System (AGMS) provides heavy anti-armor capability for attack helicopters. The first three generations of HELLFIRE missiles use a laser seeker. The fourth generation, Longbow HELLFIRE, uses a radar frequency seeker.

The first generation of Laser HELLFIRE presently is used as the main armament of the U.S. Army's AH-64 Apache and U.S. Marine Corps' AH-1W Super Cobra helicopters. The second generation currently is available for deployment. Laser HELLFIRE homes on a laser spot that can be projected from ground observers, other aircraft, or the launching aircraft itself. This enables the system to be employed in a variety of modes: autonomous, air or ground, direct or indirect, single shot, rapid, or ripple fire.

The **AGM-114A Basic HELLFIRE** tactical missile is the originally designed Hellfire missile, which is no longer purchased by the Army. A total of 31,616 were produced by both Martin Marietta and Rockwell International since 1982. AGM-114As in the inventory are released for live-fire training when they are replaced with AGM-114Cs.

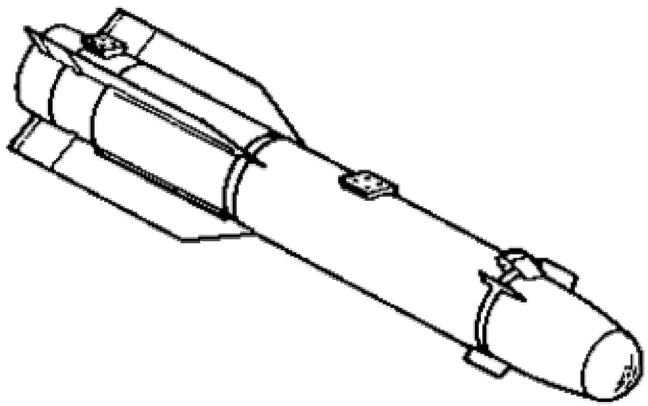
The AGM-114B, although primarily designed for Navy use, can be fired from Army aircraft. This missile has an additional electronic arm/safety device required for shipboard use.

The **AGM-114C** missile has an improved semiactive laser seeker with an improved low visibility capability. The AGM-114C has a low smoke motor and a lower trajectory than the 114A. Army missiles should be marked with either the A or C designation just behind the seeker.

The **AGM-114F Interim HELLFIRE** missile features two warheads [adding a precursor warhead to defeat vehicles equipped with reactive armor] a seeker and an autopilot similar to the C-model missile. Final delivery of the Interim HELLFIRE missiles produced by Rockwell was completed in January 1994. Production for foreign military sales continued.

The **AGM-114K HELLFIRE II** missile features dual warheads for defeating reactive armor, electro-optical countermeasures hardening, semiactive laser seeker, and a programmable autopilot for trajectory shaping. The AGM-114K missile is capable of operating with either pulsed radar frequency or A-Code laser codes for those aircraft equipped with dual code capability. Hellfire II incorporates many improvements over the Interim Hellfire missile, including solving the laser obscurant/backscatter problem, the only shortcoming identified during Operation Desert Storm. Other improvements include electro-optical countermeasure hardening, improved target reacquisition capability, an advanced technology warhead system capable of defeating reactive armor configurations

projected into the 21st century, reprogrammability to adapt to changing threats and mission requirements, and shipboard compatibility. The Initial Production Facilitation and Production Qualification Test contract was awarded to Martin Marietta in November 1992. The initial production contract was awarded in May 1993, and the second production contract was awarded in February 1994.



Version:	Basic	Interim	HF II	Longbow
Diameter:	7 in	7 in	7 in	7 in
Weight:	100 lb	107 lb	100 lb	108 lb
Length:	64 in	71 in	64 in	69.2 in

Hellfire II is the latest production version of the Laser Hellfire missile. Hellfire II and Longbow Hellfire missiles are complementary. The combination of Hellfire II's precision guidance and Longbow Hellfire's fire-and-forget capability will provide the battlefield commander flexibility across a wide range of mission scenarios, permitting fast battlefield response and high mobility not afforded by other anti-armor weapons.

For antiarmor roles, the AGM-114 missile has a conical shaped charge warhead with a copper liner cone that forms the jet that provides armor penetration. This high explosive, antitank warhead is effective against various types of armor including appliqué and reactive. Actual penetration performance is classified. It can also be employed against concrete bunkers and similar fortifications.

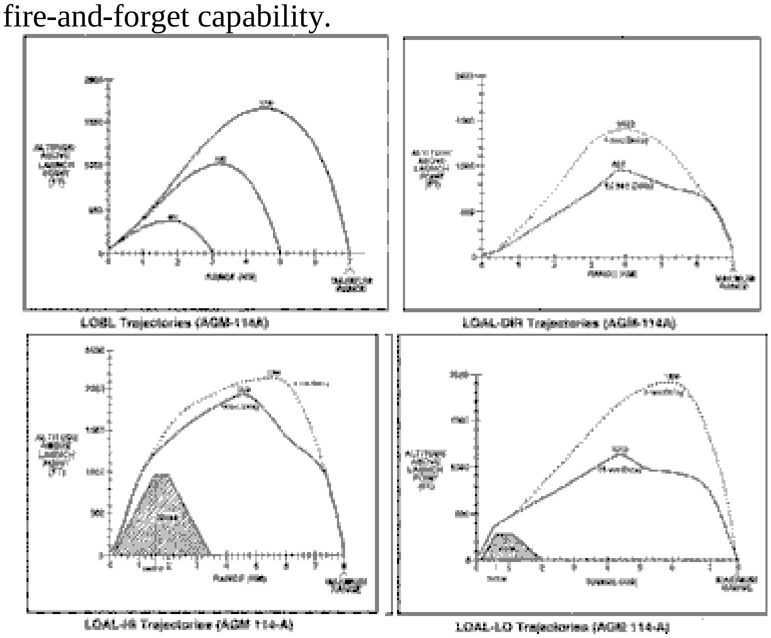
The tactical missiles are propelled by a single stage, single thrust, solid propellant motor. When thrust exceeds 500 to 600 pounds, the missile leaves the rail. Based on a 10g acceleration parameter, arming occurs between 150 to 300 meters after launch. Maximum velocity of the missile is 950 miles per hour. Maximum standoff range is a function of missile performance, launch platform altitude versus target altitude, visibility and cloud cover. Remote designation allows the launch aircraft to stand off at greater distances from the target. This standoff range can be out to the maximum missile effective engagement range.

There are different techniques for tactical employment of the Hellfire missile on the battlefield. These techniques are ultimately driven by the two engagement methods by which the missile can be controlled to the target: autonomous and remote. An autonomous engagement requires the aircraft launching the missile to guide it all the way to the target after the missile is away. In this method, a single aircraft and its crew will locate, identify, fire, and guide the missile until destruction of the target in the same way an M2/M3 Bradley crew employs its TOW missiles. In contrast, a remote engagement requires an aircraft to serve as a launch platform, providing a missile for another aircraft

or a ground observer, designating with a laser, to guide the missile to its intended target. A ground designation station such as an FO or Combat Observation Lasing Team (COLT) accomplishes this with lasing devices like the G/VLLD or MULE.

With a remote engagement, the air crew is responsible only for delivering the missile toward the general location of the target, but is no longer responsible for its guidance once it leaves the external launch rails. This allows remote engagements to provide one distinct advantage over autonomous engagements. Using this technique, the launch aircraft is often able to remain masked behind terrain, greatly reducing its visible launch signature while delivering missiles toward the target array, thereby increasing aircraft survivability - a force protection consideration. Remote engagements, however, require a great deal more coordination and plan-ning between the “shooter” and the “observer.”

In addition to the two methods of engagement, there are four modes of delivery that aircrews can utilize when firing the Hellfire missile. These delivery modes are driven by three factors: distance to the target, the weather (primarily visibility and cloud ceiling height), and terrain conditions under which the missile will be fired. When a Hellfire missile flies through obscuration (fog, clouds, smoke) or if the designator fails to lase the target properly until impact, the missile loses laser lock and will be lost for good. Only one model of Hellfire missile, the AGM-114K, has a built-in system to assist in the reacquisition of the target after laser lock-on is lost. The AGM-114L, when fielded, will provide a true fire-and-forget capability.



LOBL Trajectories (AGM-114A)

LOAL-DIR Trajectories (AGM-114A)

LOAL-HI Trajectories (AGM 114-A)

LOAL-LO Trajectories (AGM 114-A)

The first delivery mode is known as the Lock-on Before Launch (LOBL) technique. In this mode, the missile laser seeker acquires and locks-on to the coded laser energy reflected from the target prior to launch. The advantage to using this particular delivery mode is that the air crew is assured that the missile has already positively locked on to the target prior to launch from the aircraft, thereby reducing the possibility of a lost or uncontrolled missile. The disadvantages of a LOBL delivery revolve around the trajectory of the Hellfire missile. To compensate for a low cloud ceiling, an aircraft may need to expose itself to threat weapons ranges in order to ensure a successful engagement.

One method to reduce the maximum altitude of the Hellfire's flight trajectory is to select the Lock-on After Launch -Direct (LOAL-DIR) delivery mode. This delivery mode results in the lowest of all trajectories during missile flight because it is employed using a laser designation delay. Overall, depending on the length of laser delay time, the maximum altitude reached during the flight trajectory is much lower; a distinct advantage over all other delivery modes. The downside to this method, however, is that air crew is not assured of positive lock-on prior to launch.

The last two delivery modes are unique in that they allow the launch aircraft to remain masked behind terrain to reduce its firing signature and increase aircraft survivability. These delivery modes are known as Lock-on After Launch - High (LOAL-HI) and Lock-on After Launch -Low (LOAL-LO). The first mode, LOAL-HI, allows the missile to clear a 1,000 ft. high terrain feature to front of the aircraft, provided the aircraft remains a minimum of 1500 meters away from that terrain feature. This technique is most effective in a remote engagement. The major disadvantage of employing the LOAL-HI method, however, is that the missile flies the highest trajectory of all delivery modes and is most susceptible to a break in missile lock due to penetration of low-lying clouds. Using the last delivery mode, LOAL-LO, will help to reduce the maximum altitude of the Hellfire trajectory somewhat, but will also limit the size of the terrain mask utilized by the aircraft for survivability.

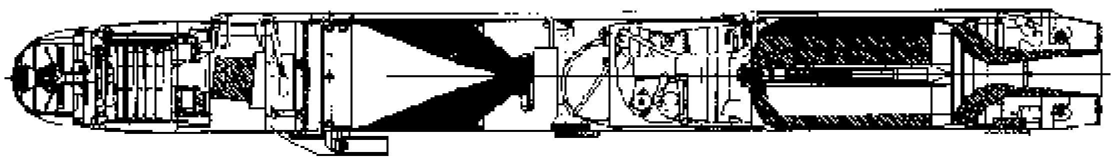
LONGBOW HELLFIRE MISSILE SYSTEM

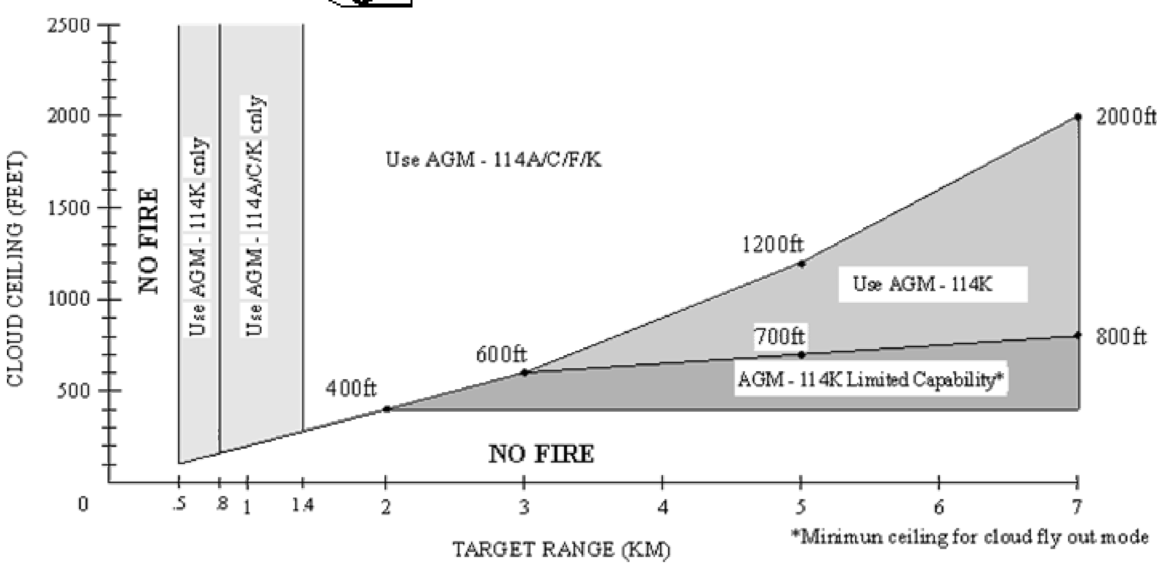
AH-64D Apache Longbow firing Hellfire Missile

The Longbow Hellfire missile will provide an adverse weather, fire-and-forget, heavy anti-armor capability for attack helicopters.The Longbow Hellfire missile is a millimeter wave radar fire-and-forget version of the Hellfire missile. The Longbow development program also includes development of a fire control radar system and numerous modifications to the helicopter. The Longbow fire control radar system will locate, classify, and prioritize targets for the Longbow Hellfire missile. The Longbow system is being developed for integration into the Apache attack helicopter and the Comanche

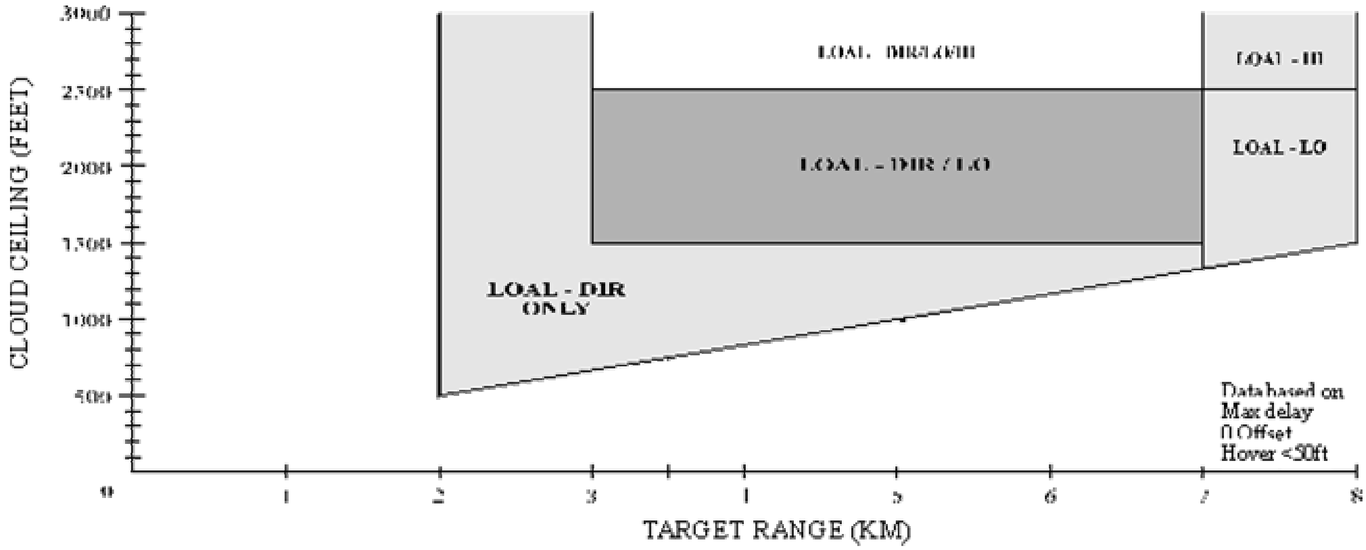
armed reconnaissance helicopter. Longbow is planned for integration into the entire fleet of Apache aircraft and into one-third of the Comanche fleet.

Longbow Hellfire incorporates a millimeter wave radar seeker on a Hellfire II aft section data bus. The primary advantages of the Longbow missile include adverse weather capability (rain, snow, fog, smoke, and battlefield obscurants); millimeter wave countermeasures survivability; fire-and-forget guidance, which allows the Apache Longbow to launch and then remask, thus minimizing exposure to enemy fire; an advanced warhead capable of defeating reactive armor configurations projected into the 21st century; and reprogrammability to adapt to changing threats and mission requirements.

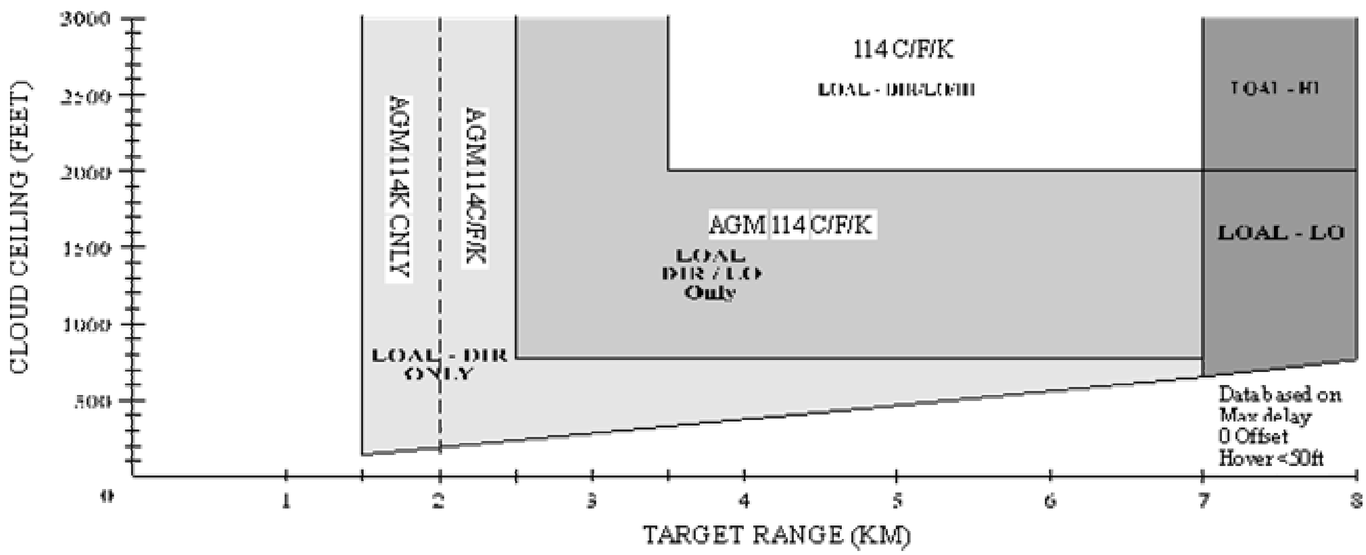




Minimum Cloud Ceiling - LOBL



AGM-114A Minimum Cloud Ceiling, LOAL



AGM-114C/F/K Minimum Cloud Ceiling, LOAL

AGM-122 Sidearm

The AGM-122 Sidearm is a small Anti Radiation Missile, carried on the Army AH 64A/D Apache and Marine Corps AH-1W SuperCobra attack helicopters for self defense against anti aircraft gun and SAM radars. The AGM-122A SIDEARM weapon system consists of an air launched guided missile, which employs passive radar detection, proportional navigation guidance, and an active optical target detecting device. The missile utilizes the LAU-7 series launcher. The SIDEARM utilizes an AIM-9C SIDEWINDER guidance section modified to detect and track a radiating ground-based air defense system radar. The target detecting device is modified for air-to-surface use, employing forward hemisphere acquisition capability. SIDEARM shares a high degree of commonality with SIDEWINDER AIM-9L/M aft components. The AIM-9L/M warhead, safe and arm device, rocket motor, and wings are redesignated SIDEARM-unique at the time they are painted green. The LAU-7 SIDEWINDER launcher provides the electronic and mechanical interface between the missile and launch aircraft. The LAU-7 internal cooling capability (nitrogen bottle) is not used for SIDEARM application.

The AGM-122A is a rebuilt AIM-9C Sidewinder, a semi-active radar homing missile using a conically scanning semi-active seeker. Originally designed for the F-8 Crusader, it was unique among the Sidewinder variants, which are all otherwise infra-red guided. In the mid-1980s several hundred of these missiles were refurbished and redesignated as the AGM-122A Sidearm in response to a Marine Corpsrequirement for a lightweight Anti-Radiation Missile to arm Marine Corps AV-8s, A-4s and helicopters.

Modifications developed at the China Lake Naval Weapons Center and produced by Motorola included improved semi-active seeker electronics to provide coverage of the greater bandwidth required to home in on a range of air defense radars. The AIM-9C's original Mk.17 motor and WDU-17 warhead were retained, with the substitution of a DSU-15 active fuse. Control electronics were modified to command an immediate pop-up after low-level launch to provide a dive attack on the target radar.

Although the resulting capability was vulnerable to countermeasures and rather limited compared to more robust anti-radar missiles such as HARM , it does provide a useful self-defense capability against low-level anti-helicopter threats such as the ZSU-23 or SA-8.

AGM-123 Skipper II

The Navy's AGM-123 Skipper II is a short range precision attack missile, consisting of a Paveway II laser guidance system and a small booster rocket attached to a Mk.83 bomb, developed by Naval Air Warfare Center Weapons Division NAWCWPNS China Lake, Skipper used the MK 78 SHRIKE, dual thrust motor for propulsion, with gravity bias incorporated for low level launch capability. Skipper II can be released at stand off ranges that may reduce exposure of delivery aircraft to enemy air defense systems. This may decrease delivery aircraft vulnerability and increase survivability.

Specifications

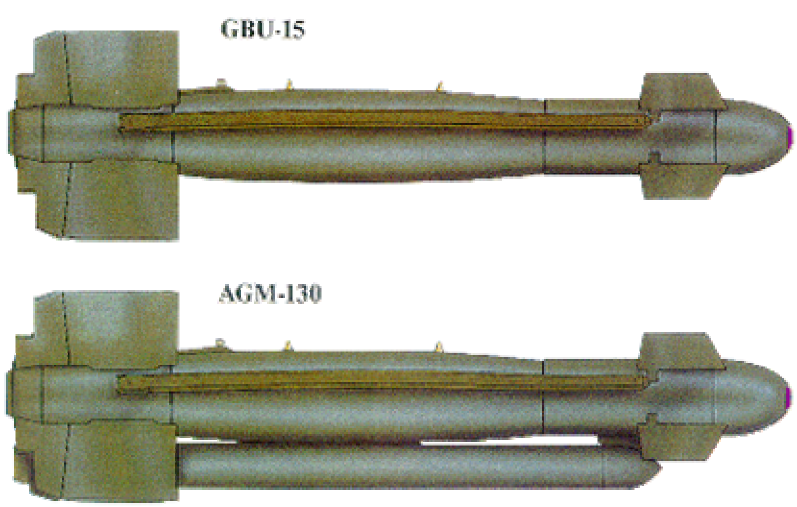
Contractor	Emerson Electric
Year	1985
Type	anti-ship powered guided bomb
Wingspan	1.6 m
Length	4.3 m
Diameter	0.5 m
Launch weight	582 kg
Max. speed	1100 km/h
Maximum range	25 km
Propulsion	tandem-mounted single stage dual thrust solid propellant rocket motors
Guidance	Paveway II passive laser
Warhead	impact-fuzed Mk.83 high-explosive bomb, 450 kg
Platforms	A-6E, A-7, F/A-18

AGM-130A

The Air-to-Ground Guided Missile-130 (AGM-130) is a powered air-to-surface missile designed for high- and low-altitude strikes at standoff ranges against a variety of targets. The AGM-130 is integrated on the F-15E which is capable of carrying two missiles, one on each inboard store station. The AGM-130 Surface Attack Guided Munition program provides the Air Force with a retargetable, precision guided standoff weapon using inertial navigation aided by Global Positioning System (GPS) satellites. The AGM-130 is designed to attack high value fixed, relocatable or slow moving targets from 15 - 40 NM range. The AGM-130A is a powered version of the Guided Bomb Unit-15 munition, and provides a significantly increased standoff range beyond that of the GBU-15. The munition allows the aircraft to remain at a distance from the target and uses man-in-the-loop guidance with either a television or infrared seeker and a 2,000-pound general purpose warhead.

Carrying forward the modular concept of the GBU-15 guided weapon system, the AGM-130A employs a rocket motor for extended range and an altimeter for altitude control. The modular AGM-130 missile consists of a charge coupled device TV or focal plane array imaging infrared seeker, adapter (with built-in radar altimeter), wings, strakes, Mk84 or BLU-109 warhead, control section, rocket motor and data link.

The AGM-130A is equipped with either a television or an imaging infrared seeker and data link. The seeker provides the launch aircraft a visual presentation of the target as seen from the weapon. During free flight this presentation is transmitted by the AXQ-14 data-link system to the aircraft cockpit monitor. The seeker can be either locked onto the target before or after launch for automatic weapon guidance, or it can be manually steered by the weapon systems officer. Manual steering is performed through the two-way data link.



For the primary mode of operation, the aircraft flies to a pre-briefed launch position. Survivability of aircraft and crew is enhanced by launching the weapon at low altitude and significant standoff range, thus avoiding detection by enemy air defenses. Precise attack is provided through the transmission of seeker signals to the aircraft data link pod attached to the controlling aircraft centerline stores station. The Weapon System Operator (WSO) operates the missile through standard cockpit controls. After launch the AGM-130 navigates to preprogrammed target area coordinates using a GPS aided inertial navigation system. The weapon flies through glide-powered-glide phases toward the target area with midcourse guidance updates provided by global positioning system (GPS) navigational information or through the data link. Upon termination of the powered flight phase the rocket motor is ejected.

As the target comes into view, the weapon systems officer has dual flexibility in guiding the weapon via the data link. For automatic terminal homing, the guidance tracker is locked on target but can be manually updated for precision bombing. When total manual guidance is used, the operator manually guides the weapon to the target aimpoint. Fifteen seconds prior to impact, the WSO locks-on to the target using the seeker tracker or manually tracks to the precise target impact point. For those aircraft not equipped with a data-link pod, the weapon may be launched in the direct attack mode (lock-on before release), as well as the primary indirect attack mode.
An additional capability is inflight missile retargeting. Real time targeting information is uploaded to the F-15E while inflight through the AXQ-14 Data link pod. The WSO then reprograms weapon target coordinates and attacks the new target.

Variants

The **AGM-130A** is designed to be used with F-15E aircraft. The AGM-130 system is capable of rapid worldwide deployment operating from main operating bases, collocated operating bases, and bare base (remote) sites. The system uses mobile support equipment to provide an organizational and intermediate level maintenance support capability. Development of the AGM-130A began in 1984 as a product improvement of the GBU-15 guided glide bomb. The first unit was operational in 1994. The acquisition category (ACAT) is ACAT II with an Air Force precedence rating of 2-06.

The **AGM-130 Mid-Course Guidance [MCG]** weapon, employs improved global positioning and inertial navigation systems. These upgrades allow the weapon to pursue targets with less involvement from the weapons systems officer in the aircraft. These new missiles have the ability to guide to the target with global positioning system steerage, freeing the hands and minds of the aircrew to concentrate on the tasks at hand in a high enemy threat environment. Two F-15Es from the 335th and 336th Fighter Squadrons at Seymour Johnson AFB NC, fired two upgraded AGM-130s during the weapon’s first launches by operational aircrews at Eglin AFB in early December 1998.

The **AGM-130LW [lightweight]** is designed with global positioning system and inertial navigation system capability permitting a single-seat fighter to launch and control the weapon. The lightweight version of the AGM-130, tested from an F-16 aircraft in 1998,

provides an all-weather, long-range precision standoff weapon for F-16C/D and F-15E aircraft increasing their standoff capability by 10-20 percent. It also provides better control over collateral damage because it does not carry as much explosive as the original AGM-130."

A further improvement, **AGM-130C**, developed, but not produced by the Air Force, adapts the munition to a 2,000-pound penetrating warhead.
The **Autonomous AGM-130** is a proposed P3I to the production weapon to incorporate an autonomous LADAR seeker. The current weapon is employs a strap-on rocket motor and utilizes an INS/GPS midcourse guidance capability. The seeker hardware would be NDI developed for a prior weapon application. Nonrecurring costs would be incurred to develop target detection algorithms for the target set specific to the AGM-130 mission. The aircraft interface would be modified to a JDAM interface. Use of the autonomous seeker will significantly reduce the mission planning timelines and reduce the aircrew workload. In addition, elimination of the datalink pod will reduce the susceptibility to countermeasures and shrink the logistic footprint.

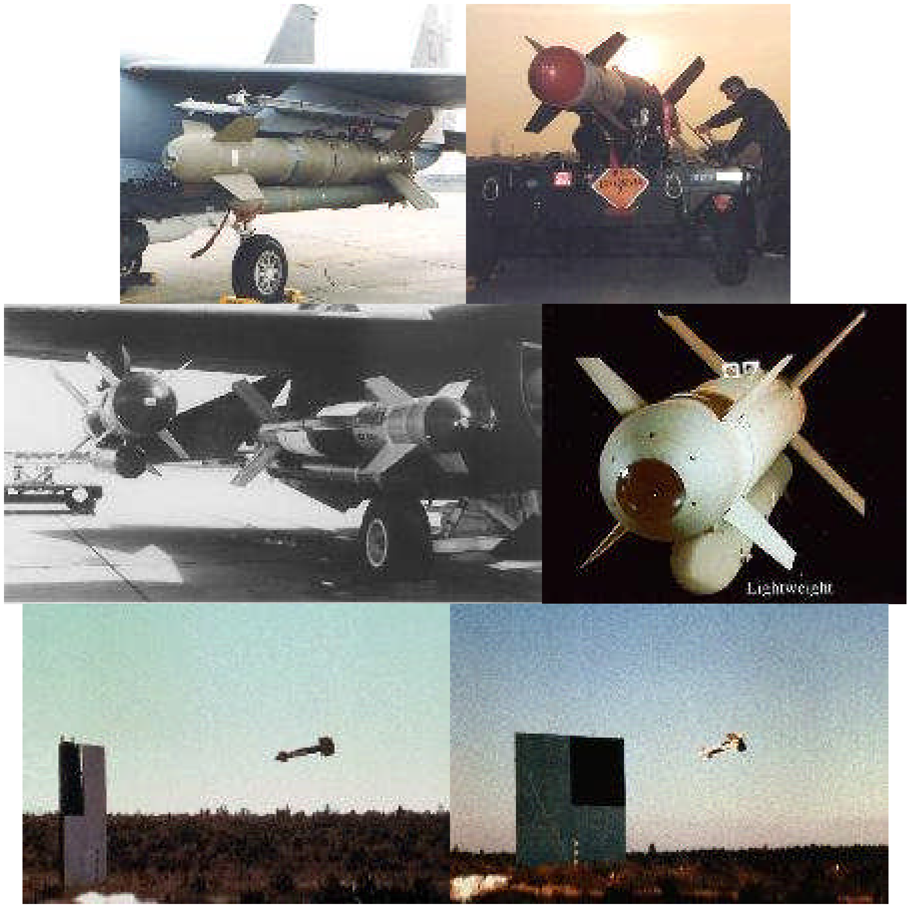
Specifications

Primary Function:	Air-to-surface guided and powered bomb
Mission	Offensive counter air, close air support/interdiction, suppression of enemy air defenses, naval anti-surface warfare
Targets	Fixed hard, fixed soft
Service	Air Force
Contractor:	Rockwell International Corp.
Thrust:	Classified
Length:	12 feet, 10.5 inches (3.90 meters)
Launch Weight:	2,917 pounds (1,312.65 kilograms)
Diameter (in.)	15/18 (bomb); 9 (rocket motor)
Wingspan:	59 inches (149.86 centimeters)
Range:	more than 40 miles
Accuracy:	
Ceiling:	30,000-plus feet (9,091 meters)
Speed:	Classified
Guidance System:	television or imaging infrared seeker
Warhead	BLU-109/MK 84
Explosive	Tritonal 945 lbs. (MK-84);

	535 lbs. (BLU-109)
Fuze	FMU-124A/B (Nose and Tail, MK-84); FMU-143 (Tail, BLU-109)
Program status	Production
Date Deployed:	December 1994 (F-111 F)
Inventory:	The missile is in production. When in the inventory the number will be classified. The Air Force had planned to buy about 4,048 kits. However, that number was reduced to about 2,300 units and for fiscal year 1995 was further reduced to 502. Currently eight lots of AGM-130 missiles have been authorized for a total procurement quantity of 674.
Development cost	$192.048 million [The cost is for the AGM-130 only. Air Force reports development cost for the AGM-130C at $11.513 million.]
Production cost	$443.908 million
Total acquisition cost	$647.47 million
Acquisition unit cost	$1.27 million
Production unit cost	$884,279 The Air Force never awarded a full-rate production contract and the production unit cost of the munition rose from an estimated $261,500 to $884,279.
Relative costs of AGM-130 components	Seeker 21%; Control 20%; Data Link 22%; Warhead 4%; Propulsion 19%; Adaptor Group 14%
Platforms	F-15E, F-111

Relative costs of AGM-130 components:

Seeker	21%
Control	20%
Data Link	22%
Warhead	4%
Propulsion	19%
Adaptor Group	14%


Lightweight

AGM-136 Tacit Rainbow

Tacit Rainbow was a project to develop a jet-powered "mini" drone for finding and destroying enemy ground based radars. Designated AGM-136A by the Air Force, the Tacit Rainbow could be carried to target striking distance and air-launched by bombers or fighters, or launched from ground systems. Each vehicle was preprogrammed for a designated target area using the on-board computer and flight control system. Once launched, AGM-136A flew a preprogrammed course to its target area and "loitered" until it detected transmissions from an enemy radar. Once a radar source is detected and identified, the UAV homed in to destroy it. Unlike other anti-radiation missiles, Tacit Rainbow could not be "fooled" if the radar was turned off to avoid being hit. As long as fuel remained, it could wait and reattack that or another radar when operation resumed.

The Tacit Rainbow unmanned aerial vehicle (UAV) was conceived in the early 1980s using experience gained with anti-radar missiles in Vietnam. Its purpose was to supplement manned aircraft in striking enemy air defenses. The vehicle was designed for low cost production so that it could be used in "swarms" against dense enemy air defense networks.

The Naval Research Advisory Committee (NRAC) 1989 Summer Study on "Defense Suppression in the Year 2000" recommended the development a family of decoys (that is inexpensive, realistic, modular, easy to carry onboard strike aircraft and carrier compatible, including a lethal version) for use in conjunction with strike operations to saturate the enemy IADS, and noted that Tacit Rainbow did not meet these requirements.

The first Tacit Rainbow air-launch occurred on July 30, 1984. More than 30 test launches were made, from both bombers and fighters. The MLRS launcher was also used for the Ground Launched Tacit Rainbow.
On 21 March 1989 the Acting Secretary of the Air Force notified the Congress that the current program acquisition unit cost of the Tacit Rainbow program had increased by more than 15 percent, and on 23 May 1989 notification was provided that the Tacit Rainbow Program has exceeded its baseline unit cost by more than 15 percent.

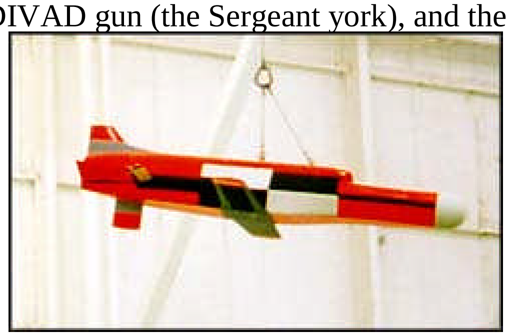
Procurement funding for the Tacit Rainbow missile was deferred by the Congress in October 1989, pending successful completion of operational testing. The next year's budget request for Fiscal Year 1991 contained $9.759 million to continue development of Tacit Rainbow anti-radiation cruise missile. The budget request also contained $227.4 million for procurement. Subsequently, the Air Force formally informed the Congress that an additional $27.0 million would be required in research and development funding because of delays in the program. The House authorized $26.759 million for research and development, endorsing the increase in funding requested by the Air Force. The House also provided $59.5 million for procurement, which was earmarked in the budget request for facilitating the factory of the follow-on competitor for the Tacit Rainbow program. The House restricted the obligation of the $59.5 million until the Secretary of the Air Force submitted a report evaluating the cost effectiveness of proceeding with two

production contractors for the Tacit Rainbow program. The Senate authorized $36.759 million for research and development, and authorized the procurement funds as requested. The conferees recommend an authorization of $36.759 million for research and development and $59.5 million for advance procurement and agreed to the legislative provisions proposed by the House.

The ground-launched version of the nonnuclear TACIT RAINBOW ALCM had a design range of only 430 kilometers, and was therefore well below the newly agreed START threshold of 600 kilometer range for counting ALCMs.

Tacit Rainbow was a purely conventional system and there were no plans to equip it with nuclear warheads; therefore, the 1990 Strategic Arms Reduction Treaty [START] agreement did not have any effect on the US ability to employ it. The Soviet effort to capture Tacit Rainbow was part of their overall effort in START to try to constrain US conventional programs. The ALCM range issue in the START negotiations was a question of what range would mark the threshold between short-range systems not limited by START in any way and long-range nuclear ALCMs which would be covered by START. The US concern on ALCM range was above all to protect US conventional options. Since future non-nuclear ALCMs like Tacit Rainbow will not be limited by START if they are externally distinguishable from nuclear ALCMs, the US accepted the 600 kilometer range threshold in START. As a result of its tough negotiating on this provision, the United States gained concessions which eased the way for the deployment of new conventionally armed cruise missiles such as the highly accurate Tacit Rainbow. Secretary of State Baker agreed to constrain US military programs in a so-called `side letter' to the proposed START framework statement in which the United States agreed not to modernize the Tacit Rainbow ALCM, and also not to equip this ALCM with a nuclear warhead. This letter informed the Soviets of the fact that the US had no plans to convert the non-nuclear Tacit Rainbow ALCM to a nuclear ALCM.

In October 1990 Air Force investigators looking into mismangement at Northrop concluded that many of the expensive weapons systems built by that contractor -- including the B-2, the Tacit Rainbow anti-radar missile, the F-15's jamming system, the guidance system for the MX missile -- were riddled with fraud and performance defects. The program was cancelled for budget reasons in 1991, prior to the planned start of production in 1992. During the previous two decades, only two programs were cancelled after full scale testing had commenced and before a substantial amount of serial production: the Army's DIVAD gun (the Sergeant york), and the Tacit Rainbow missile.



Specifications

Span	5 ft. 2 in.
Length	8 ft. 4 in.
Body diameter	2 ft. 3 in.
Weight	430 lbs.
Armament	WDU-30/B 40 lb. blast fragmentation warhead
Engine	Williams International F121 turbofan of 70 lbs. thrust
Cost	$200,000 (estimated production version)
Cruising speed	Subsonic
Range	air-launched = "More than 50 miles" ground-launched = 430 kilometers

Tri-Service Standoff Attack Missile TSSAM

In 1986, the Air Force began developing TSSAM to provide a low observable conventional cruise missile. Key characteristics included long-range, autonomous guidance, automatic target recognition, and precision accuracy with a warhead able to destroy a well-protected structure.
The Tri-Service Standoff Attack Missile (TSSAM) was a joint service program with the Air Force as the lead service. The program objective was to develop a family of highly survivable, conventional, stealthy cruise missiles to satisfy tri-service requirements to effectively engage a variety of high value land and sea targets. The technical approach to develop a modular stealth cruise missile which can employ several payloads and guidance systems to engage the required targets. All variants used a GPS aided inertial navigation system. The Navy and Air Force (unitary variant) missiles used an imaging infrared terminal sensor for autonomous recognition and homing on fixed land targets and sea targets. The other Air Force variant contained the Combined Effects Bomblet (CEB) submunition to attack land targets. Integration efforts were planned for the Air Force's B-52H, F-16C/D, B-1 and B-2 and the Navy's F/A-18C/D.

TSSAM was touted as the most silver of bullets because of its low observability capability.

Northrop Aircraft Division's cost/schedule control system did not provide the Government with reliable data and the data was not promptly submitted; therefore, the Joint System Program Office could not effectively measure the contractor's performance or use the cost data to make informed management decisions. Management of TSSAM Program funds was fragmented among the three Military Departments, resulting in an awkward budgeting process, funding shortfalls, and delays in program and contracting decisions.

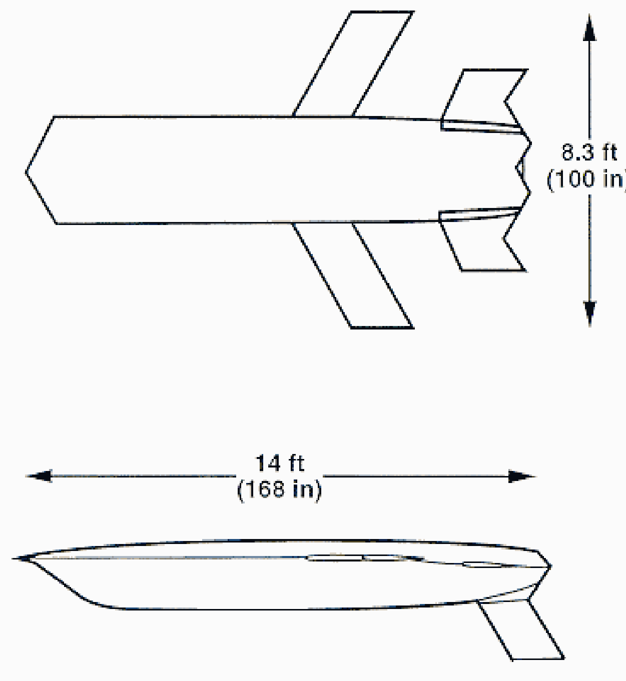
The system had significant development problems, and estimates of the unit cost in production were unacceptably high. That made it a logical candidate for cancellation. After the TSSAM procurement unit cost increased from an estimated $728,000 in 1986 to $2,062,000 in 1994 (then-year dollars), the Department of Defense (DOD) terminated the program. On 09 December 1994 the Secretary of Defense announced cancellation of the TSSAM program. DEPSECDEF Program Decision Memorandum (PDM) IV, 16 Dec 94, canceled the TSSAM and associated contracts. Many TSSAM program specifics remain SECRET -Special Access Required per the 31 March 1993 Program Security Guide. Following a comprehensive reassessment of force requirements, the Air Force and Navy agreed they urgently needed an affordable missile with most of TSSAM's characteristics. They proposed a joint program that would build upon the lessons learned from TSSAM and more recent programs that use new acquisition approaches. On September 20, 1995, the Principal Deputy Under Secretary of Defense for Acquisition and Technology approved the initiation of the JASSM program, under Air Force leadership.

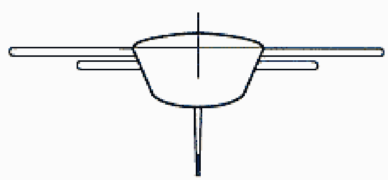
The publicly released retouched photo of TSSAM revealed the vehicle's stealthy shape, but little of engine ports or sensors.

Tri-Service Standoff Attack Missile (TSSAM)

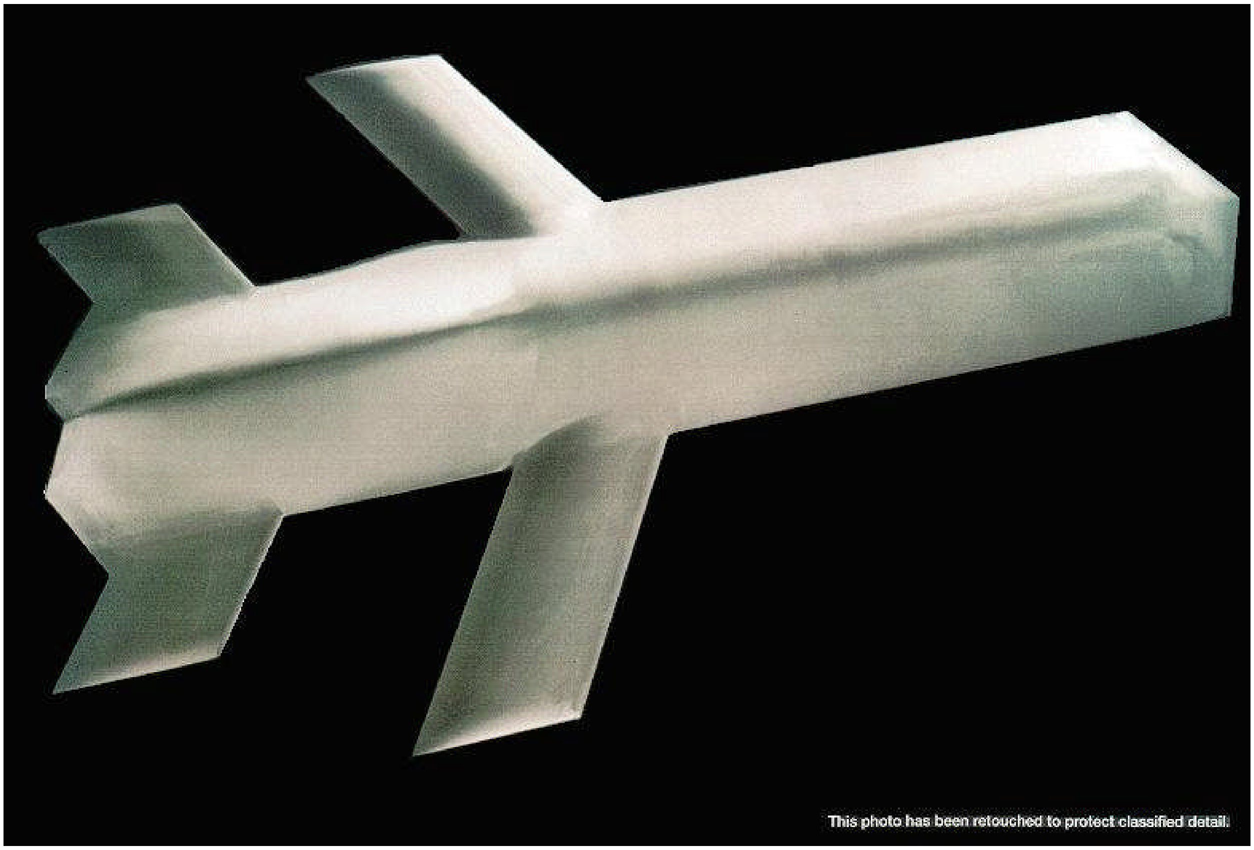
CHARACTERISTICS	
Length	14 ft
Max Weight	Approx 2000 lbs
Warhead Class	1000 lbs
Type	CEB/Unitary
Range	100 nm+
Enroute Guidance	INS W/GPS Updates
Terminal Guidance	IIR – Unitary Variants
Man-in-the-Loop	Navy Variant Only
Propulsion	Turbofan

Platforms	Loadout
B-52H	12 (External)
B-1	8 (Internal)
B-2	8 (Internal)
F-16C/D	2
F/A-18	2





NORTHROP GRUMMAN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AGM-142 Raptor
Popeye I Have Nap
Popeye II Have Lite

The AGM-142 Have Nap is an Israeli-built Popeye missile being acquired by the USAF. The AGM-142 is a medium range conventional stand off missile provides the Air Force with a precision man-in-the-loop capability for the B-52H to attack high value, fixed targets from standoff ranges. The AGM-142 provided the first precision guided munitions capability for the B-52H platform. The program is managed by the Precision Strike System Program Office at Eglin Air Force Base, Florida and is produced by Precision Guided Systems United States (PGSUS) of Orlando, Florida. Work on the AGM-142 system is performed at Lockheed Martin Missiles and Fire Control - Orlando, in Orlando, Fla., and Troy, Ala., and at locations in Israel.

The Have Nap has an inertial guidance system with data link, TV, or imaging infra-red homing. The munition's data link provides for single aircraft operation or the munition's guidance may be turned over to a second aircraft allowing the first aircraft to leave the area. The AGM-142 weighs 3000 lbs. It is 190 inches long, 21 inches in diameter, has a wing span of 78 inches, and is powered by a solid propellant rocket motor. The missile has a range in excess of 50 nautical miles. Warheads and seekers are modular and allow for four missile configurations. The AGM-142 can be assembled with a 750-pound blast fragmentation warhead or an I-800 penetration 770-pound warhead and can employ either a television or an imaging infrared seeker.
Have Nap, although a very capable weapon system, was not used during Desert Storm. The Air Force Gulf War Airpower Study speculated that it was not used because of the policy implications of launching an Israeli-made weapon against an Arab country. Representative targets for Have Nap include power plant transformers, generators, and cooling towers; POL refinery cracking/ distillation towers; radar or communication site control vans/buildings; and research and development facilities. Upgrades to the Have Nap weapon system ongoing after Desert Storm included an imaging infrared seeker and an I-800 penetrating warhead.
The AGM-142, currently in production, incorporates a Producibility Enhancement Program (PEP) that was initiated in October 1993. The program has gone through a series of three PEP efforts that have reduced missile costs and decreased logistics and maintenance requirements while increasing maintainability and overall operational capability. The PEP efforts consisted of changes in the manufacturing process and materials for the rocket motor casing and missile wings and fins, new Inertial Measurement Unit (IMU), a new closed loop imaging infrared seeker, and an upgraded processor with corresponding reduction of the circuit card assemblies in the missile electronics section.
The newest addition to the AGM-142 missile system is Producibility Enhancement Program (PEP) III. PEP III is a new type of infrared seeker (referred to as a Z-Seeker) and new software to make the system work with future test sets. PEP III went through

extensive testing at Barksdale AFB in April 1998. This was a combined test by the developers and the users. Because PEP III gives the users a third seeker, the total number of possible configurations is nine: three seekers on three types of electronics sections. All nine configurations went through all testing.

In May 1998 the AGM-142 Program Office awarded a contract to PRB Associates of Hollywood, MD to produce an AGM-142 Air Force Mission Support System (AFMSS) Weapon Planning Module (WPM). When delivered, the module will allow B-52 radar navigators to plan AGM-142 missions using the same AFMSS system they use to plan aircraft missions. The SPO used an innovative acquisition approach to save the Air Force time and money. Because of the similarity between the AGM-142 and the AGM-130 missions, about 70% of the code PRB developed for the AGM-130 AFMSS WPM will be re-used in the 142 effort. The SPO modified an existing AGM-130 AFMSS contract with PRB to produce the AGM-142 planning module. The re-use of code saved approximately $600K and 6 months of schedule.

The US Air Force originally purchased and accepted 154 missiles. An additional 54 missiles (Lot 7, FY 96) were in production as of mid-1999 and are the first delivered from Lockheed Martin's missile manufacturing facility in Troy, Alabama.

Internationally, AGM-142 has been purchased by the Israeli Air Force, the Royal Australian Air Force, and as of August 1999, the Republic of Korea Air Force. On 15 February 1999 the U.S. Air Force awarded PGSUS LLC, a Lockheed Martin/Rafael joint venture, a contract modification for production and delivery of AGM-142 air-to-surface precision strike standoff missiles to the Royal Australian Air Force (RAAF), under the U.S. Foreign Military Sales program. The action modified a contract awarded to PGSUS in September 1998, covering production of up to 250 AGM-142s for US and foreign military sales. The total contract value now stands at $133.3 million, with the joint venture partners sharing about equally. Australia first announced its intention to buy the precision strike weapon for its fleet of F-111 fighters in 1996. A Letter of Agreement for the sale was signed December 14, 1998.

Turkey initially bought 50 Popeye I missiles for its fleet of F-4s being upgraded at Israel Aircraft Industries. At least 40 Popeye I missiles were delivered to Turkey in 1997 with a second batch of 60 shipped in 1998. In May 1997 Israel and Turkey agreed to jointly produce the Popeye II air-to-ground missile in a deal initially worth about $100 million dollars. The new deal involved a consortium to be established between two Turkish firms and Rafael to jointly produce the Popeye II, a smaller missile with more advanced technology. The Popeye II, also known as the Have Lite, is designed for deployment on fighter aircraft and has a range of 150 kilometers. The Popeye II missiles were expected to be delivered beginning in 2000. The overall Popeye-I and Popeye-II missiles program with Turkey was valued at some $500 million.

In December 1999 press reports suggested the possibility of the sale of Popeye II missiles to India. US officials told Israel that they were concerned about sales of arms to India because of tensions in the region.

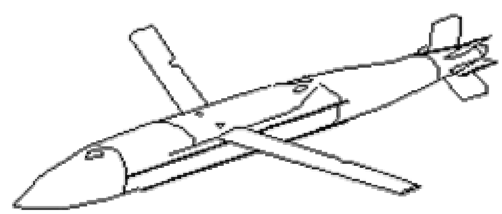
Specifications

Missions	Offensive counterair, interdiction, suppression enemy air defense, naval anti-surface warfare
Targets	Mobile soft, fixed hard, fixed soft, maritime surface
Service	Air Force
Program status	Production
First capability	1992
Guidance method	Television and imaging infrared (man- in-the-loop)
Weight	3,000 lbs / 1,360 kg
Warhead Weight	750 lbs / 340 kg
Length	15ft 10in / 4.8 meters
Length	1ft 9in / 0.533 meters
Range	45 miles / ~75 km
Quantity	130
Development cost	$67.6 million
Production cost	$133.1 million
Total acquisition cost	$200.7 million
Acquisition unit cost	$1.54 million
Production unit cost	$1.02 million
Platforms	B-52H

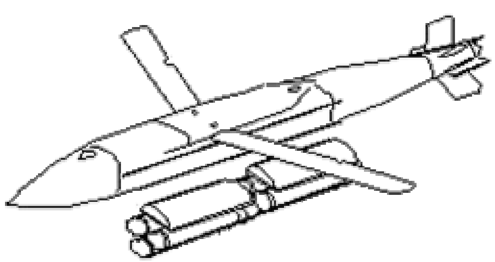

AGM-154A Joint Standoff Weapon [JSOW]

The AGM-154A Joint Standoff Weapon or JSOW is currently under development by Raytheon [Texas Instruments] for the Air Force and the Navy. The AGM-154A (Formerly Advanced Interdiction Weapon System) is intended to provide a low cost, highly lethal glide weapon with a standoff capability. JSOW family of kinematically efficient, air-to-surface glide weapons, in the 1,000-lb class, provides standoff capabilities from 15 nautical miles (low altitude launch) to 40 nautical miles (high altitude launch). The JSOW will be used against a variety of land and sea targets and will operate from ranges outside enemy point defenses. The JSOW is a launch and leave weapon that employs a tightly coupled Global Positioning System (GPS)/Inertial Navigation System (INS), and is capable of day/night and adverse weather operations. The JSOW uses inertial and global positioning system for midcourse navigation and imaging infra-red and datalink for terminal homing.

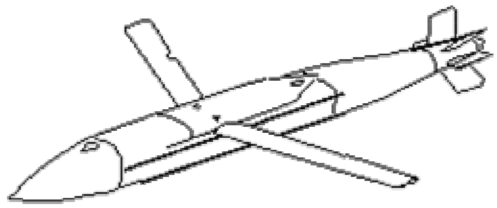
The JSOW is just over 13 feet in length and weighs between 1000-1500 pounds. Extra flexibility has been engineered into the AGM-154A by its modular design, which allows several different submunitions, unitary warheads, or non-lethal payloads to be carried. The JSOW will be delivered in three variants, each of which uses a common air vehicle, or truck, while substituting various payloads.



AGM-154A (Baseline JSOW) The warhead of the AGM-154A consists of 145 BLU-97/B submunitions. Each bomblet is designed for multi-target in one payload. The bomblets have a shaped charge for armor defeat capability, a fragmenting case for material destruction, and a zirconium ring for incendiary effects.



AGM-154B (Anti-Armor) The warhead for the AGM-154B is the BLU-108/B from the Air Force's Sensor Fuzed Weapon (SFW) program. The JSOW will carry six BLU-108/B submunitions. Each submunition releases four projectiles (total of 24 per weapons) that use infrared sensors to detect targets. Upon detection, the projectile detonates, creating an explosively formed, shaped charge capable of penetrating reinforced armor targets.



AGM-154C (Unitary Variant) The AGM-154C will use a combination of an Imaging Infrared (IIR) terminal seeker and a two-way data link to achieve point target accuracy through aimpoint refinement and man-in-the-loop guidance. The AGM-154C will carry the BLU-111/B variant of the MK-82, 500- pound general purpose bomb, equipped with the FMU-152 Joint Programmable Fuze (JPF) and is designed to attack point targets.

Texas Instruments (TI) Defense Systems & Electronics (DS&E) began Engineering and Manufacturing Development (E&MD) of JSOW in 1992. In December 1995, the Navy and Texas Instruments completed Development Test IIB (DT-IIB) at the Naval Air Weapon Center, (NAWC) China Lake and Point Mugu, California, with 10 for 11 successful flights of the AGM-154A BLU-97 dispenser variant.

On January 6, 1997, it was announced that Texas Instruments Defense Systems & Electronics was being purchased by Raytheon Company, Lexington, Massachusetts. The U.S. Navy began Operational Evaluation (OPEVAL) testing in February 1997, after successful development testing and initial operational testing programs. The test program resulted in a 42 for 44 success rate or greater than 96% successful JSOW launches. The Air Force began Development Test & Evaluation (DT&E) flight testing of JSOW on the F-16 at Eglin Air Force Base, Florida, in March 1996. Air Force testing of the baseline JSOW was hindered by less than desired progress in the area of F-16/JSOW integration. There was never a problem in the interface between the weapon and the aircraft. The weapon worked perfectly. The problem that prolonged the testing at Eglin, was with a subassembly of the JSOW, which was not manufactured by Texas Instruments.

AGM-154A (Baseline variant) system entered Low Rate Initial Production (LRIP) on schedule. The $65.9 million LRIP contract was awarded by the Naval Air Systems Command (NAVAIR), in Arlington, Virginia, for 111 JSOW AGM-154A/baseline systems. LRIP for the other two variants are scheduled for FY99 and FY00, respectively. On 29 December 1998 Raytheon Systems was awarded a $133,881,355 firm-fixed-price contract to provide funding for the Full Rate Production Lot 1 of JSOW AGM-154A and the Low Rate Initial Production Lot I of the JSOW AGM-154B (AGM-154A: Navy - 328 and Air Force - 75) (AGM-154B: Navy - 3 and Air Force - 21). Work is expected to be completed by March 2001.

JSOW test articles were deployed in 1997 aboard the USS Nimitz and are currently deployed on the USS Eisenhower. JSOW initial introduction to the operational commands was on the Navy/Marine Corps F/A-18 in mid-1998. As of late 1997 a number of remaining JSOW test assets were on an interim deployment for further operational evaluation. USS Carl Vinson 's air wing first employed the JSOW during combat over southern Iraq on Jan. 25, 1999.

On 29 December 1999 Raytheon Systems Company, Tucson, Ariz., was awarded a $109,573,867 modification to previously awarded contract N00019-99-C-1014 to exercise an option for the full rate production Lot 2 of the Joint Standoff Weapon AGM-154A for the U.S. Navy (414) and U.S. Air Force (74). Work will be performed in Tucson, Ariz., and was expected to be completed by March 2002.

On 23 June 2000 Raytheon was awarded a $5,069,914 modification to previously awarded cost plus incentive fee basic ordering agreement N00019-98-G-0104 for the integration of the Selective Availability Anti-Spoofing Module (SAASM) into the Joint Standoff Weapon (JSOW) System. This effort will bring new production JSOWs delivered after 1 April 2003 in compliance with current Global Positioning System (GPS) security requirements for weapon-based GPS. Work will be performed in Tucson, Ariz., and is expected to be completed by May 2001.

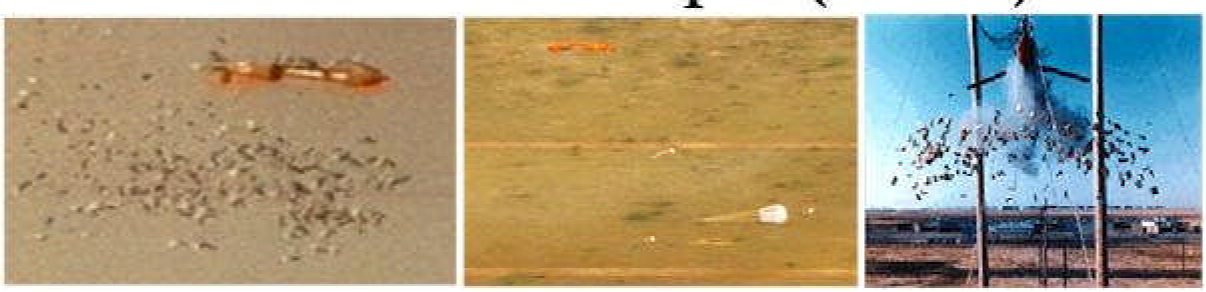
Weapon planning will be accomplished using the Navy's Tactical Automated Mission Planning System (TAMPS) and the Air Force Mission Support System (AFMSS). Aircraft-to-weapon communications will be via the MIL-STD-1760 interface, making inflight programming/targeting possible, as well as preflight data loading. The weapon will be deployed from both carrier- and land-based aircraft, employing insensitive munitions technology. The JSOW will be employed on the following aircraft: F/A-18A/B, C/D, and E/F; AV-8B; F-14A/B and /D; F-16C/D; F-15E; F-117; B-1B; and B-52.

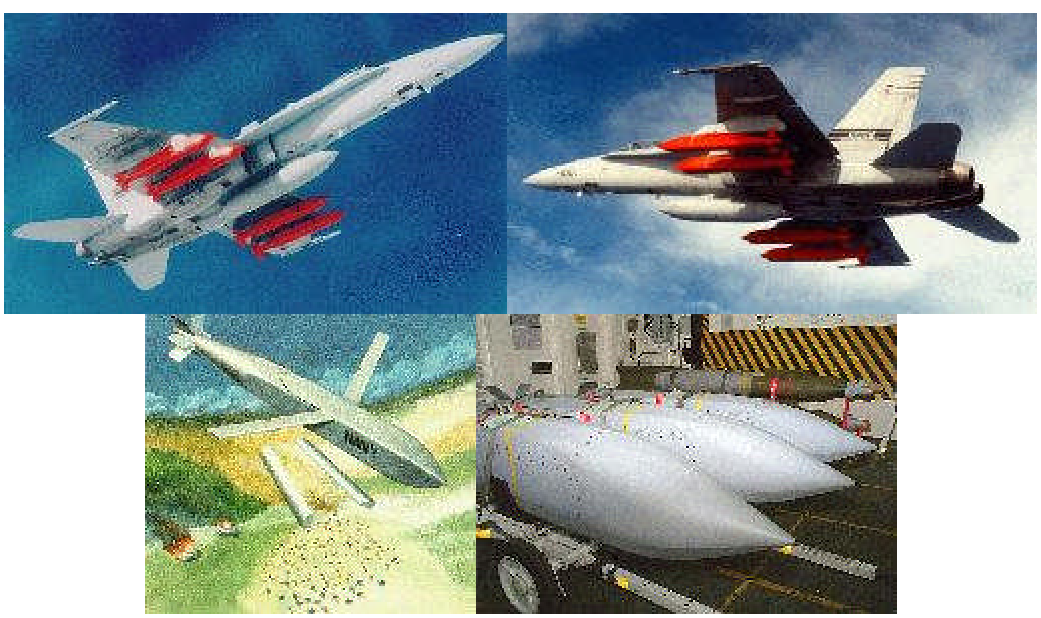
Specifications

Mission	Close air support, interdiction, amphibious strike and anti-surface warfare		
Variants	AGM-154A Baseline	AGM-154B Anti-Armor	AGM-154C Unitary
Service	Navy and Air Force	Navy and Air Force	Navy
Contractor	Raytheon [Texas Instruments]		
Targets	Mobile soft, fixed soft	Mobile hard, mobile soft	Fixed hard, maritime surface
First capability	1998	2001	2002
Guidance method	GPS/INS	JSOW airframe -- GPS/INS BLU-108 submunitions -- two-color infrared sensors	GPS/INS with a terminal seeker and man- in-the-loop data link
Range	12 nm (24km) Low altitude launch (unpowered)		

	40 nm (64 km) High altitude launch (unpowered) ->120 nm (200 km) Powered		
Circular Error Probable			
Development cost	$417.9 million	$227.8 million	$452.4 million
Production cost	$2,909.7 million	$1,805.7 million	$5,155.9 million
Total acquisition cost	$3,327.6 million	$2,033.5 million	$5,608.3 million
Acquisition unit cost	$282,000	$484,167	$719,012
Production unit cost	$246,585	$429,929	$661,013
Quantity	Navy: 8,800; Air Force: 3,000	Navy: 1,200; Air Force: 3,000	Navy 7,800
Platforms	B-1, F-16, F-15E, F/A-18C/D, F/A-18E/F, AV-8B, P-3, S-3	B-1, F-16 C/D, F-15E, F/A-18C/D, F/A-18E/F, AV-8B, P-3, S-3	F/A-18C/D, F/A-18E/F, AV-8B, P-3, S-3

Joint Standoff Weapon (JSOW)














NAWCWD

AGM-158 Joint Air to Surface Standoff Missile (JASSM)

The Air Force/Navy Joint Air to Surface Standoff Missile (JASSM) program was established in the fiscal year 1996 budget, following cancellation of the Tri-Service Stand-off Attack Missile (TSSAM), to develop a replacement for that system at the earliest possible date. In light of the urgent need for the operational capability that would have been provided by the TSSAM, the Secretary of Defense established a joint program in the Air Force and the Navy for development of a replacement for TSSAM, canceled for escalating program cost, that would meet the requirements of both services. After the termination of the TSSAM, the Services continued to reiterate the need for a high survivability standoff weapon capable of attacking a variety of deep interdiction type targets. The Joint Requirements Oversight Council revalidated the need for the weapon in an August 1995 mission need statement.

JASSM is a precision cruise missile designed for launch from outside area defenses to kill hard, medium-hardened, soft, and area type targets. The threshold integration aircraft are the F-16, B-52, and F/A-18 E/F, and the airframe design is compatible with all JASSM launch platforms: the B-52H, F-16C/D, F/A-18E/F, F-15E, F-117, B-1B, B-2, P-3C and S-3B. The weapon is required to attack both fixed and relocatable targets at ranges beyond enemy air defenses. After launch, it will be able to fly autonomously over a low-level, circuitous route to the area of a target, where an autonomous terminal guidance system will guide the missile in for a direct hit. The key performance parameters for the system are Missile Mission Effectiveness, range, and carrier operability.

JASSM's midcourse guidance is provided by a Global Positioning System (GPS)-aided inertial navigation system (INS) protected by a new high, anti-jam GPS null steering antenna system. In the terminal phase, JASSM is guided by an imaging infrared seeker and a general pattern match-autonomous target recognition system that provides aimpoint detection, tracking and strike. It also offers growth potential for different warheads and seekers, and for extended range.

Initially, the program entertained proposals from seven contractors. The build-up to the Request for Proposal release was a period of intense interaction between all contractors and the government team. A 24-month JASSM Program Definition and Risk Reduction contract was awarded to McDonnell Douglas by the Department of Defense on June 17,

1996. A downselect to one contractor for the engineering and manufacturing development and full-rate production phases occured in April 1998 with the selection of Lockheed-Martin. The Navy has proposed to replace the joint program for JASSM with the Navy's SLAM-ER, prior to completion of the current program definition and risk reduction phase for JASSM. The proposal is one of the program alternatives that may be considered at the Milestone II review for entry of the JASSM program into engineering and manufacturing development in July 1998, which will evaluate the technical progress in the program and risk reduction phase, cost and operational effectiveness analysis, and other factors.

Low-rate initial production decision for JASSM is in the year 2000, with full-scale production scheduled to run from 2002 to 2009. Total missile production for the U.S. Air Force is expected to be 2,400 missiles; the total for the U.S. Navy is yet to be determined. The total program is valued at approximately $3 billion.

Potential Upgrades

The JASSM P-LOCAAS-DM P3I concept integrates powered LOCAAS submunitions with dual mode LADAR and MMW seeker. LOCAAS has a multimode warhead and a maneuvering airframe to produce a high performance submunition . The warhead can be detonated as a long rod penetrator, an aerostable slug, or as fragments based on the hardness of the target. The LADAR allows target aimpoint and warhead selection to be determined automatically. The powered LOCAAS uses a small turbojet engine which is capable of powering the vehicle for up to 30 minutes. JASSM will provide the delivery platform for LOCAAS thus increasing the range and operational flexibility of LOCAAS.

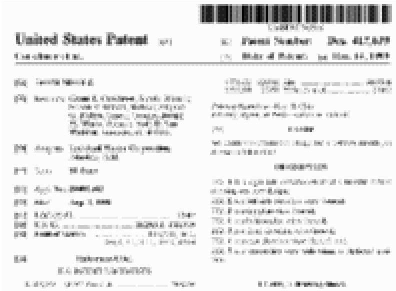
The JASSM Penetrator concept is a P3I to the Joint Air-to-Surface Standoff Missile (JASSM) to replace the baseline warhead with an advanced penetrator that meets or exceeds the objective penetration requirement specified in the JASSM Operational Requirements Document (ORD) and to add a synthetic aperture radar (SAR) seeker for adverse weather precision attack capability. The warhead concept is a 1000 pound dense or ballasted penetrator. The warhead would either be designed with a dense metal case or contain dense metal ballast for maximum penetration. The warhead will be filled with advanced insensitive explosive to compensate for the reduced charge weight. The JASSM will be compatible with the B-52, F-16, F/A-18 (threshold), B-1, B-2, F-15E, F-117, S3, P3 and JSF (objective). This concept uses the Hard Target Smart Fuze (HTSF), an accelerometer based electronic fuze which allows control of the detonation point by layer counting, distance or time. The accelerometer senses G loads on the bomb due to deceleration as it penetrates through to the target. The fuze can distinguish between earth, concrete, rock and air.

In December 1998 the development of JASSM was slowed, following concerns that the program’s development schedule was "too aggressive." The engineering and manufacturing development (EMD) phase was extended from 34 to 40 months. Another reason given for the extended schedule was that the Theater Battle Management Core System, on which the JASSM will rely, is not yet year 2000-compliant. The JASSMs,

costing approximately $300,000 per unit, will be tested beginning in February 1999 at Eglin and at White Sands Missile Range.

Specifications

Missions	
Targets	hard, medium-hardened, soft, and area fixed and relocatable targets
Service	Air Force
Program status	
First capability	
Guidance method	Global Positioning System (GPS)-aided inertial navigation system (INS)
Range	nautical miles
Quantity	usaf - 2,400 USN - TBD
Development cost	$ million
Production cost	$ million
Total acquisition cost	$ 3 Billion
Acquisition unit cost	$ million
Production unit cost	$700,000
Platforms	B-52 (12) FY01 B-1 (24) FY02 B-2 (16) FY03 F-16 (2) FY04 F-16C/D F/A-18E/F F-15E F-117 P-3C S-3B


United States Patent

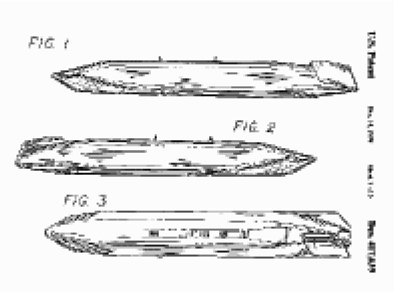


FIG. 1
FIG. 2
FIG. 3

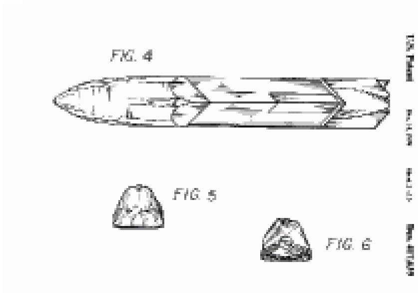


FIG. 4
FIG. 5
FIG. 6

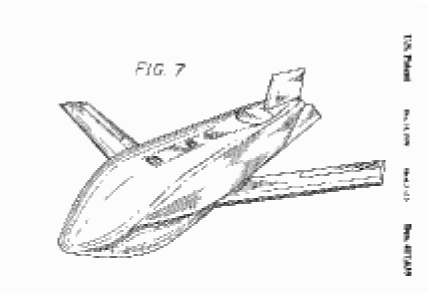
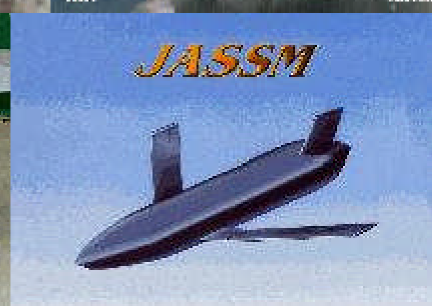
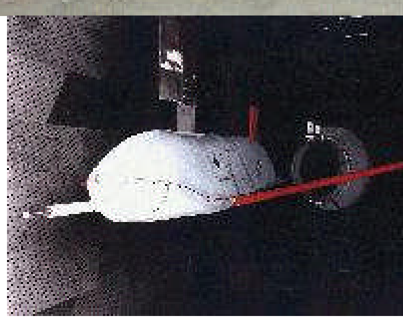


FIG. 7


JASSM


JASSM




ED
ET

AGM-119B *Penguin* Anti-Ship Missile

The *Penguin* is a helicopter launched anti-ship missile developed for use on Lamps III helicopters and NATO allies. Penguin is the only operational Navy helicopter-launched missile in the Navy's weapon inventory. It provides Navy surface combatants with a defense against surface threats armed with antiship missiles.

The PENGUIN missile is a short-to-medium range inertially guided missile with infrared (IR) terminal homing. The missile consists of a seeker, navigation and control section, warhead,rocket motor, four folding wings and four canards. It is capable of gravity drop launches at low speeds and altitudes. Ships and surfaced submarines are the missiles primary targets. A principal operational advantage of Penguin is its relatively long operational range, which permits a helicopter armed with Penguin to remain outside the launch envelopes of potential targets. The *Penguin* missile has an indirect flight path to target. It is also operated in "fire-and-forget" mode to allow multiple target aqusition. The *Penguin* is fired from a launcher or a stage weighing approximately 1100 pounds (500 kilograms).

The Penguin is a uniquely capable weapon against small combatants and surfaced submarines in the littoral environment. The IR seeker head is effective against a wide range of targets and its profile is hard to defend against. It is a short-to-medium range inertially guided missile and is capable of gravity drop launches at low speeds and altitudes. A "fire-and-forget" missile, the Penguin has a 360 degree arc, autonomous search, acquisition and track during terminal phase, discriminates between target decoys and is resistant to IR countermeasures.

The PENGUIN weapon system consist of the AGM-119B guided missile, Missile Launcher Assembly (MLA), and Missile Control System (MCS). The MLA contains the MCS and attaches to the pylons of the SH-60B LAMPS MKIII Helicopter and provides mechanical attachment points for missile launch/release system a (BRU-14 bomb rack with two AERO-1A adapters). The MLA, with BRU-14 attached, carries and launches the PENGUIN on command. The MCS is an integral part of the MLA. The MCS is located in the MLA and provides the interface between the helicopter and the missile for control, transfer of data, and electrical power during captive flight. The MCS contains the alignment unit,missile power unit, alignment power unit, umbilical release unit, and umbilical and interconnecting cables.

Penguin is a fully digitized missile with canard control. The high resolution, passive infrared seeker provides a high degree of discrimination and target selection, and ensures efficient operation in confined, as well as open waters. The high accuracy, inertial

navigation system ensures the missile's capability of target detection, and provides the flexibility of mid-course trajectory via pilot-designated way-point.

An efficient 120 kg warhead, with an impact point close to the target's waterline, will inflict serious damage to medium size surface combatants or other targets. The missile is powered by a solid propellant two stage rocket motor. The Penguin can be adapted to helicopters, fixed wing patrol aircraft as well as fighter aircraft. The missile system is software integrated into the aircraft avionic system. with the use of existing equipment for suspension, control and operation.

The PENGUIN missile is a helicopter launched version of the Norwegian MK 2 MOD 3 missile which has been modified and designated as an MK 2 MOD 7. The *Penguin* was developed by and for the Norwegian Navy. The Penguin missiles are designed and manufactured by Norsk Forsvarsteknologi (NFT) A/S located in Kongsberg, Norway. The Penguin anti-ship missile was conceived in the early 1960's as a ship-borne, anti-invasion defence system. Penguin was the first fire-and-forget anti-ship missile system to be developed in the Western world. Penguin MKI became operational with the Norwegian and Turkish navies in 1972. The MK2 entered service in 1980 with the Norwegian, Hellenic and Swedish navies. Since then, continuous development programs have adapted the concept to the technical evolution of surface warfare.

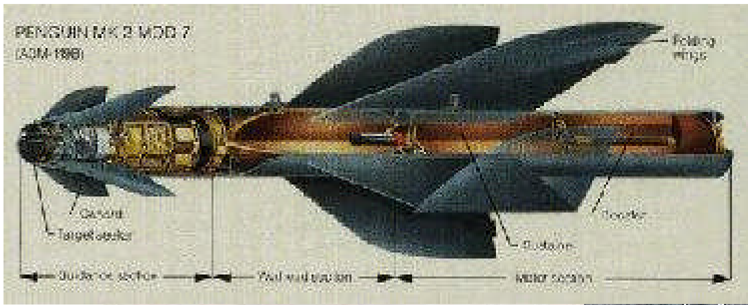
The air-launched penguin MK3 version (AGM-119A) was chosen as the standard anti-ship missile for the F-16 Fighting Falcons of the Royal Norwegian Air Force. and has completed a highly successful Foreign Weapon Evaluation Program conducted by the US Air Force. Navy testing of Penguin has been completed, and it achieved IOC in the fourth quarter of FY 1993. The successful first fleet firing of an AGM-119 Penguin anti-ship missile by the HSL-51/USS HEWITT (DD-966) team on June 25, 1994, completed the transition of the SH-60B "Seahawk" from an anti-ship surveillance and targeting (ASST) platform to an anti-surface (ASUW) weapon system. The initial operating capability (IOC) was completed at the Pacific Missile Range Facility (PMRF) Barking Sands, Hawaii during RIMPAC '94 with the INDEPENDENCE Battle Group. The direct hit by the telemetry round against the YOG-79 target hulk resulted in the ninth successful Penguin launch by the U.S. Navy. The first eight were completed in 1990 during Techeval/Opeval by Rotary Wing Test Directorate and VX-1. The Navy will acquire approximately 100 Mod 3 versions. The Penguin MK2 MOD7 (AGM-119B) with folding wings is adapted to the US Navy LAMPS Mk III, SH-60B helicopters. All Block I modified SH-60Bs will be capable of employing Penguin, and eventually all SH-60Bs operating from US Navy FFG-7 and DD-963 Class Ships.

The National Defense Authorization Act for Fiscal Year 1997 contained a provision that authorized the Navy to enter into a contract for multiyear procurement of not more than 106 Penguin missiles and limited the amount that could be expended for such procurement to $84.8 million. This provision was based on the existing shortfall in Penguin missile inventory and the premise that the Navy would be able to negotiate a very favorable price at around 55 percent of the average unit procurement cost for

previous lots. Congress subsequently appropriated $7.0 million to procure Penguin missiles in fiscal year 1997 and $7.5 million in fiscal year 1998.

Specifications

Primary Function	Helicopter launched anti-ship missile.
Contractor	Kongsberg Vaapenfabrikk (Norway)
Power Plant	Solid propellant rocket motor and solid propellant booster
Length	120.48 inches (3.06 meters)
Launch Weight	847 pounds (385 kilograms)
Diameter	11.2 inches (28.45 centimeters)
Wing Span	30 in's folded, 55 in's Deployed
Range	25 nautical miles / 35 km
Speed	1.2 Mach maximum
Guidance	Inertial and infrared terminal.
Warhead	265 lbs gross, 110 lbs High Explosive, semi armor piercing derivative of the Bullpup missile
Date Deployed	Fourth quarter 1993


PENGUIN MK 2 MOD 7
Folding wings
Target seeker
Guidance section
Motor section

HAWK

The HAWK surface to air missile system provides medium-range, low to medium altitude air defense against a variety of targets, including jet and rotary wing aircraft, unmanned aerial vehicles, and cruise missiles. This mobile, all-weather day and night system is highly lethal, reliable, and effective against electronic countermeasures. The Hawk was originally named for the predatory bird but later the name was turned into an acronym for "Homing All the Way Killer."

The HAWK system has provided US forces with low to medium altitude air defense for the past forty years. The Hawk System has been the Marine Corp's primary air defense since the early 1960's. Basic HAWK was developed in the 1950s and initially fielded in 1960. The system has been upgraded through a series of product improvements beginning with the Improved HAWK in 1970. The Phase III product improvement and the latest missile modification were first fielded in the early 1990s to the US Army and US Marine Corps (USMC). The system has maintained it's effectiveness against succeeding generations of high technology aircraft through periodic preplanned product improvement programs. An evolving system, HAWK is now in its Phase III configuration with research and development underway to obtain a tactical missile defense capability.

This success lead many NATO countries to adopt HAWK as a primary air defense weapon. Today, HAWK systems are in the arsenals of over fifteen countries, including most of NATO countries. In the coming years, HAWK will continue its prominent position by undergoing system upgrades to allow it to deal with the changing nature of the battlefield threat.

Although HAWK missile batteries were deployed by the U.S. Army during the conflicts in Vietnam and Persian Gulf, American troops have never fired this weapon in combat. The first combat use of HAWK occurred in 1967 when Israel successfully fired the missiles during the Six Day War with Egypt. Even though it was not used by the coalition during Operation Desert Storm, the HAWK missile did see action during the Persian Gulf War. Kuwaiti air defense units equipped with U.S. HAWK antiaircraft missiles downed about 22 Iraqi aircraft and one combat helicopter during the invasion of 2 August 1990.

Current developments will provide an engagement capability against Tactical Ballistic Missiles (TBM). The US Marine Corps and the Ballistic Missile Defense Organization (BMDO) have jointly funded improvements to the Marine Corp's HAWK system. The HAWK has been modified and tested to intercept short-range ballistic missiles. Because HAWK is a well established system, the current program of upgrades and enhancements is seen as a low risk, near-term missile defense solution against short-range ballistic missiles and other airborne threats such as aircraft or unmanned aerial vehicles. In this role, HAWK can be considered a lower-tier missile defense system. All US HAWK

systems are owned and operated by the Marine Corps and, as the Marine's only ballistic missile defense system, it will be relied on to protect Marine expeditionary forces. In September 1994, two LANCE target missiles were successfully intercepted by the modified HAWK system in an operational test by Fleet Marine Forces at White Sands Missile Range, New Mexico. By the end of 1997 over one third of the active Marine Corps HAWK equipment has been modified to provide a basic, short-range tactical ballistic missile defense (TBMD) for expeditionary Marine forces. The entire fleet inventory was modified by the end of 1998 year.

Units with HAWK missiles are teamed with acquisition radar, a command post, a tracking radar, an Identification Friend or Foe (IFF) system, and three to four launchers with three missiles each. The system can be divided into three sections: acquisition, fire control, and firing sections. Target detection is provided to the fire control section from pulse and continuous wave radars for engagement evaluation. Target data can also be received from remote sensors via data link. The fire control section locks onto the target with high-powered tracking radar. A missile or missiles can be launched manually or in an automatic mode from the firing section by the fire control section. Radars and missile have extensive electronic counter counter measures (ECCM) capabilities.

The HAWK Fire Unit is the basic element of the HAWK system.. The actual firing battery has two identical fire units, each consisting of a command post that houses the operator console, a continuous wave acquisition radar (CWAR) for target surveillance, a high power illuminator for target tracking, MK XII IFF interrogator set, and three launchers with three missiles each. Normally the HAWK is deployed in a battalion configuration, communicating with the controlling unit (usually a TSQ-73 Missile Minder) over an Army Tactical Data Link (ATDL-1) connection as well as on voice.

The TSQ-73 Missile Minder Fire Direction Center (FDC) is the system used for the Army HAWK Battalion and Air Defense Brigade. The TSQ-73 supplies command, control and communications for the Army fire units (both Patriot and HAWK) and provides a link to the Air Force C3I units (MCE and AWACS). The Brigade and HAWK battalion units rely on information passed over the data links to produce a comprehensive air picture, while the HAWK battalion can also deploy the Pulse Acquisition Radar (PAR) to generate its own air picture. With the command and control of Army fire units being moved to the Information Coordination Center (ICC) and Army ADTOC (Air Defense Tactical Operations Center), the TSQ-73 is gradually being phased out over the next several years. However, it still plays a vital role in the coordination of SAM assets into the integrated theater air defense environment.

The new HAWK systems will be composed of three major components: the TPS-59 radar, the HAWK launcher and HAWK missiles, and the Air Defense Communications Platform (ADCP). The TPS-59 radar provides target detection, discrimination, and tracking. The HAWK launcher transports, protects and launches the missiles. Each HAWK launcher can carry up to three missiles. HAWK missiles use radar guidance and destroy their targets in proximity explosions. Finally, the ADCP will connect the TPS-59 with the HAWK and the remainder of the theater missile defense architecture in order to create missile defense in depth. Under the current program, the TPS-59 radar and the HAWK launcher and missiles are being upgraded, while the Air Defense Communications Platform [ADCP] will be a new addition.

The most prominent upgrade to the HAWK system includes modifying the Marine Corps primary air surveillance radar, the TPS-59. The AN/TPS-59 Radar Set is a Marine Air Command & Control System which serves as the primary sensor for the Marine Air Ground Task Force (MAGTF), providing air target information and raw video to the Tactical Air Operations Module (TAOM). It can also be forward-deployed as a stand-alone remote sensor and air traffic controller. The improved radar will detect theater ballistic missiles out to 400 nautical miles and up to 500,000 feet in altitude. These improvements will give the radar the sort of surveillance and tracking ability needed for theater ballistic missile defense (TBMD). The first units were equipped with upgraded TPS-59s in FY98.

The Air Defense Communications Platform, an entirely new addition to the HAWK system, will link the TPS-59 to the HAWK battery and will also transmit formatted data to other theater sensors. This will allow the HAWK to communicate with other TBMD systems through the Joint Tactical Information Distribution System. These links will allow the air defense commander to cue HAWK with other missile defense systems and integrate the HAWK into the theater missile defense architecture. The ADCP is fully developed, and began production in FY97.

The HAWK missile and warhead were modified to allow the HAWK to better engage enemy ballistic missiles. Specifically, the upgrade improved the HAWK's missile fuse and warhead which resulted in an "improved lethality missile." Additionally, improvements to the launcher made the HAWK more mobile and better able to interface with the missiles.

These new HAWK systems underwent extensive testing. In August of 1996, a single Marine Corps battery equipped with upgraded HAWK systems intercepted and destroyed a LANCE short range theater ballistic missile and two air breathing drones simultaneously in an operational test at White Sands Missile Range, NM. When fielded, the upgraded TPS-59 radars and ADCPs will belong to the Marine Air Control Squadrons, part of the Marine Air Wings.

Specifications

Service	Marine Corps
Contractor	Raytheon
Mission	surface-to-air missile defense
Targets	
Length	12.5 feet (3.81 meters)
Diameter	13.5 inches (3.84 centimeters)
Weight	1400 pounds (635 kilograms)
Range	Officially: 14.9 miles (24 kilometers) 40 km, in excess of 20 NM

Speed	Officially: Supersonic 800 m/sec, in excess of mach 2.4
Altitude	Officially: 30,000 feet (9.14 kilometers) in excess of 60 KFT
Propulsion	Solid propellant rocket motor
Guidance system	Radar directed semi-active homing
Warheads	One 300 pound (136.2 kg) high explosive missile
Type of fire	Operator directed/automatic modes
Magazine capacity	48 missiles/battery
Missile guidance	Semi-active homing
Target detection	Continuous wave radar and pulse acquisition radars
Target tracking	High power illuminating continuous wave radar and passive optical
Rate of fire	1 missile every 3 seconds
Sensors	High power continuous wave radar (HIPIR) Continuous wave acquisition radar (CWAR) Pulse Acquisition Radar (PAR) and passive optical scan
Transport	C-130/C-141/C-5 and heavy lift helo (extended load)
Deployment	One Light Antiaircraft Missile Battalion in each Marine Air Control Group of each Marine Air Wing (two active, one Reserve). Firing Platoon: 2 Fire sections of up to 3 Launchers per (1) PAR and (1) CWAR 3 missiles per launcher
Units	2 active duty and 1 reserve Light Anti-aircraft Missile Battalion
Crew	*Officer:* 2 *Enlisted:* 49
Program status	Operational
First capability	Air Defense - 1962 Missile Defense -
Quantity	total inventory is 37,000 missiles
Development cost	
Production cost	
Total acquisition cost	

Acquisition unit cost	
Production unit cost	
Unit Replacement Cost	$250,000 per missile $15 million per fire unit $30 million per battery

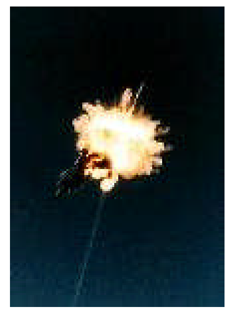

HAWK Launch, August 21, 1996 (35K)


HAWK Launch Versus LANCE, December 7-8, 1996 (62K)

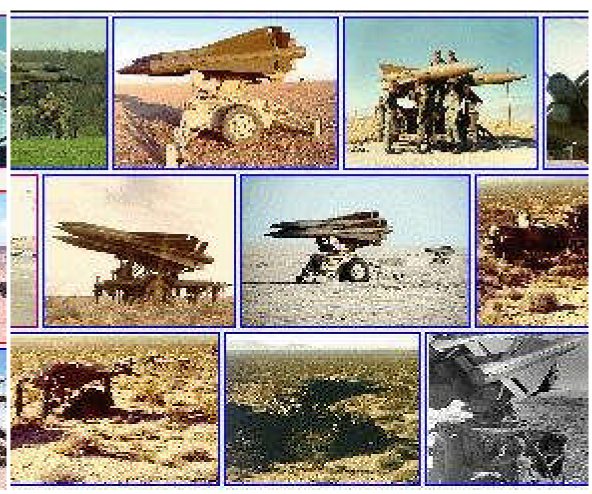

HAWK Versus LANCE, December 7-8, 1996 (33K)

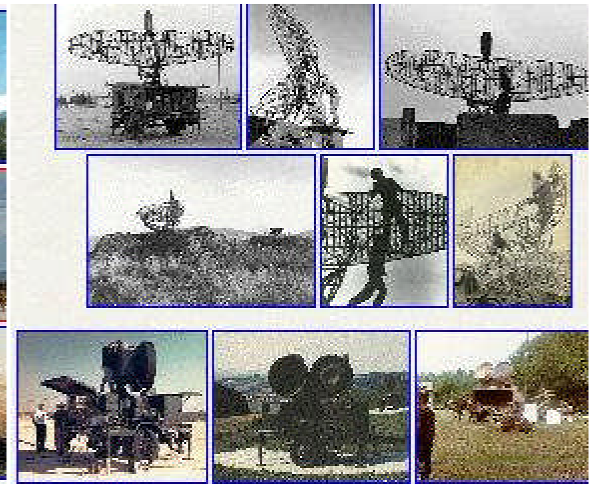

HAWK Versus LANCE End Game, December 7-8, 1996 (40K)


HAWK Versus LANCE Impact, December 7-8, 1996 (22K)


HAWK Versus LANCE Impact, December 7-8, 1996 (32K)


HAWK Image Gallery - 1


HAWK Image Gallery - 2



HAWK In Flight **HAWK Radars**

MIM-72 / M48 Chaparral Forward Area Air-Defense System [FAADS]

The Chaparral provides mobile short-range air defense to defeat low-altitude aircraft. The system is designed to be mobile, self-contained and air transportable. A mobile light air defense system with a turret mounted on a tracked vehicle carrying four ready-to-fire missiles, the Chaparral is a ground launched version of the air-to-air Sidewinder. Chaparral consists of an infrared heat seeking missile, a launcher with a Forward Looking Infrared (FLIR) sight, and a tracked vehicle. Chaparral was the Army's standard, short range, low altitude air defense system which provided point defense of vital corps areas against direct air attack. The missile is lightweight, supersonic, fire-and-forget, with an infrared homing guidance system capable of engaging fixed-wing and helicopter targets. To enhance missile acquisition range and capability the Rosette Scan Seeker (RSS) guidance section has been developed and is effective against infrared jammers. The missile is carried and handled as an assembled single round of ammunition. Used against helicopters and low flying fixed-wing jets, it homes in on the heat given off by the target aircraft's engine exhaust. Although US forces never fired this missile in combat, the system has been successfully used under such conditions by allies of the United States.

The Chaparral Fire Unit may be used either carrier mounted or unmounted. The launcher contains a rotating mount that includes four missile launch rails and provides the gunner the means to aim and fire using automatic or manual tracking. Eight additional missiles are stowed in the vehicle.

The system uses an M-730A2 cargo carrying, self-propelled tracked vehicle "9a" variant of the M-113 Armored Personnel Carrier, which can be made amphibious by adding an existing swim kit. A towed configuration is also available.

The associated Forward Area Alerting Radar (FAAR) was a D-band pulse doppler radar used to detect low flying aircraft and provide alerting and tentative identification to CHAPARRAL and VULCAN fire units and Manportable Air Defense (MANPAD) teams. The radar had a range of about 20 kilometers, contained the Mark XII Identification, Friend or Foe (IFF) system, and transmitted digital data to the target alerting data display sets (TADDS) located with each CHAPARRAL/VULCAN battalion. The FAAR section consisted of three men and one vehicle and trailer.

This system was made by Loral Aerospace Corporation at a cost of $80,000 per missile and $1.5 million per fire unit. The Army had a total of 596 Fire Units with 5,358 missiles on hand in the early 1990s. Based on a December 1994 decision, Chaparral is being deactivated and removed from the US Army National Guard inventory. This action was completed by the end of FY 1997.

Specifications

Length	114.5in (2.91m)
Body diameter	5.0in (12.7cm)
Span	25in (64cm)
Launch weight	185lbs (84kg)
Propulsion	Rocketdyne MK36 Mod 5 single-stage solid motor
Guidance	Initial optical aiming. IR homing to target heat emitter
Maximum range	About 5,250 yards (4,800m)
Maximum effective altitude	About 8,200 ft (2,500m)
Flight speed	About mach 2.5
Warhead	28lbs (12.7kg) continuous rod HE

Chaparral Image Gallery

Patriot TMD

Patriot can be transported worldwide via C5 cargo plane. Built in diagnostic software; the computer tells you what's wrong with the system, making maintenance and repair much easier. Patriot battalions can interface with Hawk battalions and with the Air Force AWACS.

Major Components

1. Phased array radar. It's beam is electronically aimed at a different piece of the sky every few microseconds. No moving parts. Extremely difficult to jam.

2. Engagement Control Station (ECS). Where the computer and the operators fight the air battle. Man-machine interaction options here can range from letting the computer assist in target identification and prioritization to leaving the ECS and letting the computer fight the entire air battle itself.

3. 6 to 8 missile launchers. Missiles come factory packed in containers which are loaded directly onto the launcher. The Launcher can be located up to 1 kilometer away from the ECS/Radar, receiving commands automatically via microwave data link.

4. Patriot missile. Achieves supersonic speed within 20 ft of leaving the launcher. Range: 100+ km. It can outmaneuver any manned aircraft and most missiles. It is controlled in flight automatically by the computer.

Patriot-unique equipment at the Headquarters and Headquarters Battery (HHB) includes the information and coordination central (ICC), communications relay groups (CRGs), antenna mast groups (AMGs), trailer mounted electric power units (EPUs), and guided missile transporters (GMT). The Patriot firing battery equipment includes the AMG, radar set (RS), engagement control station (ECS), truck mounted electric power plant (EPP), and up to sixteen launching stations (LSs). Both the battalion and firing batteries are equipped with a semitrailer maintenance center.

(1) The ICC is manned during air battle operations and provides necessary command and control links to interface with higher echelon, lateral and subordinate battalions, and its own firing units.

(2) The ECS is the only manned station in the battery during the air battle and is the operations control center of the Patriot battery. The ECS contains the weapons control computer (WCC), man/machine interface and various data and communication terminals. Its prime mover is a 5-ton tactical cargo truck.

(3) The RS is a multifunction, phased-array radar mounted on an M860 semitrailer. The prime mover is an M983 10-ton heavy expanded mobility tactical truck (HEMTT) tractor.

(4) The LS is a remotely operated, fully self-contained unit, carrying integral on-board power. The launcher is mounted on an M860 semitrailer towed by a M983 HEMTT 10-ton tractor. Each LS may be loaded with four PAC-2 missile rounds (MRs), or 16 PAC-3 missile rounds if the LS is PAC-3 modified. The MR consists of a Patriot missile mounted within a sealed aluminum canister that functions both as a shipping and storage container and as a launch tube. Canisters are either single or 4-packs and are mounted two by two on the launcher.

(5) The CRG provides a multi-routed, secure, two-way data relay capability between the ICC and its assigned fire units and adjacent units. The CRG also provides the capability for both data and voice exit and entry point communications with elements external to the Patriot ADA battalion.

(6) The AMG consists of four ultra high frequency (UHF) antennas used for communications between the ICC, CRG, ECS and adjacent units and or higher echelons. The AMG can be remotely controlled in azimuth from within the ECS.

(7) The EPP consists of two 150-kw generator sets, a power distribution unit (PDU), cables, and accessories mounted on a modified HEMTT. The PDU is stored between the generators and contains a parallel powerbus and power contractors to supply prime power to the ECS and RS.

Testing of Patriot's response to a unique, advanced electronic countermeasure (ECM) technique exposed an air defense system weakness and recommended corrective measurees. Over 155 Patriot surveillance investigations and 6 missile firings were completed in extensive ECM environments consisting of stand-off jamming, selfscreening jamming, and chaff.

In February 1995, the U.S. Army took delivery of the first PATRIOT Advanced Capability-2 (PAC-2) Guidance Enhanced Missile (GEM). The GEM incorporates improvements to the front end of the PAC-2 missile receiver to enhance its effectiveness and lethality against SCUD-class ballistic missiles. The U.S. Army will field about 350 PAC-2 GEM missiles.

Patriot Advanced Capability-3 (PAC-3)

Patriot Advanced Capability-3 (PAC-3) is a high/medium advanced surface-to-air guided missile air defense system. PAC-3 is a major upgrade to the Patriot system. The PAC-3 Operational Requirements Document (ORD) represents the Army Air Defense need to buy back required battlespace lost against the current and evolving tactical missile and air breathing threat. PAC-3 is needed to counter/defeat/destroy the 2008 threat and to extend Patriot's capabilities to accomplish new/revised missions.

The PAC-3 Program consists of two interrelated acquisition programs - The PAC-3 Growth Program and the PAC-3 Missile Program. The Growth program consists of integrated, complementary improvements that will be implemented by a series of phased, incrementally fielded material changes. The PAC-3 Missile program is a key component of the overall improvements of the Patriot system, it will provide essential increases in battlespace, accuracy, and kill potential.

PAC-3 is a much more capable derivative of the PAC-2/GEM system in terms of both coverage and lethality. The PAC-3 has a new interceptor missile with a different kill mechanism--rather than having an exploding warhead, it is a hit-to-kill system. The PAC-3 missile is a smaller and highly efficient missile. The canister is approximately the same size as a PAC-2 canister but contains four missiles and tubes instead of a single round. Selected Patriot launching stations will be modified to accept PAC-3 canisters.

The Battalion Tactical Operations Center (BTOC) is an M900 series 5-ton expandable van that has been modified by the addition of data processing and display equipment, and utilized by the battalion staff to command and control the Patriot battalion. The BTOC allows the staff to perform automated tactical planning, communications link planning, and to display situational awareness information.

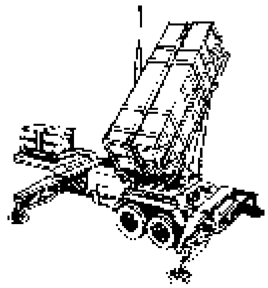
In the 1997 budget DOD added about $230 million for the PAC-3 through the Future Years Defense Program (FYDP) and established a realistic schedule to lower the program execution risk by extending the engineering and manufacturing development (EMD) phase of the program by ten months. System performance will be improved by re-phasing the missile and radar procurements; upgrading three launchers per battery with Enhanced Launcher Electronics Systems; and extending the battery’s remote launch capability. PAC-3 Low-Rate Initial Production (LRIP) will begin in the second quarter of fiscal year 1998, and the First Unit Equipped (FUE) date is planned for the fourth quarter of fiscal year 1999. The FUE capability will consist of 16 missiles and five radars which will be placed in one battalion. As of 1996, in addition to funds being programmed for the Ballistic Missile Defense Organization, the Army planned to spend $9.6 billion for all planned purchases of Patriot missiles, $490 million for modifications and $335 million for product improvements.

Specifications			
	PAC - 1	**PAC - 2**	**PAC - 3**
Type	Land-mobile, surface-to-air guided weapon system	Single-stage, low-to-high-altitude	Single-stage, short-range, low-to high-altitude
Length	5.3 m	5.18 m	5.2 m

Diameter	41 cm	41 cm	25 cm
Wingspan		92 cm	50 cm
Fins	four delta shaped fins		
Launch Weight	914 kg	900 kg	312 kg
Propulsion	Single-stage solid propellant rocket motor	Single-stage solid propellant rocket motor	Single-stage solid propellant rocket motor with special attitude-control mechanism for in-flight maneuvering
Guidance	Command guidance and semi-active homing, track-via-missile (TVM)	Command guidance with TVM and semi-active homing	Inertial/Active millimeter-wave radar terminal homing
Warhead	HE single 90 kg	91 kg HE blast/ fragmentation with proximity fuze	hit-to-kill + lethality enhancer 73 kg HE blast/fragmentation with proximity fuze]
Max speed	Supersonic (in excess of Mach 3)	Mach 5	Mach 5
Max range	70 km	70-160? km	15 km
Min range	NA	3 km	--
Max attitude	NA	24 km	15 km
Time of flight		• minimum nine seconds • maximum three and a half minutes	
Launcher	four-round Mobile trainable semi-trailer		eight-round Mobile trainable semi-trailer
Manufacturer	Raytheon	Raytheon (Prime contractor),	Lockheed Martin Vought Systems

		Lockheed, Siemens, Mitsubishi.	
Status	Not in production	In production	Under Devlopment

Patriot / Patriot PAC-2










[PATRIOT Air Defense System (289K)]

[PATRIOT Features (55K)]


[Additional PATRIOT Features (60K)]

[PATRIOT Fire Unit (310K)]

[PATRIOT Launcher Station(265K)]

[PATRIOT Radar (444K)]


PATRIOT PAC-2 Antenna Mast Group(46K)


PAC-2 Radar (47K)


Lance Target Missile Launch (34K)


Camouflaged PAC-2s Desert Storm (62K)


PAC-2 Leaving Launch Canister (56K)


PATRIOT Launch (56K)


PATRIOT Launcher (80K)


Desert Location (60K)


PAC-2 Deployed (80K)

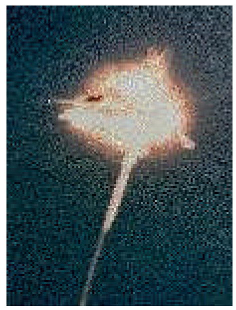

PAC-2 on the Move (97K)

Patriot PAC-3 ERINT

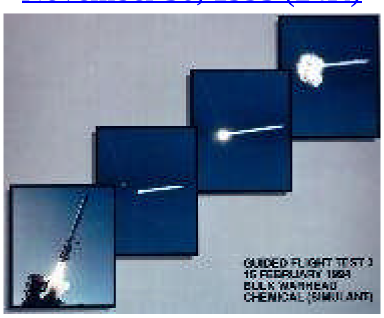
ERINT Dem/Val Seeker with Radome (70K)

PAC-3 Radar (89K)

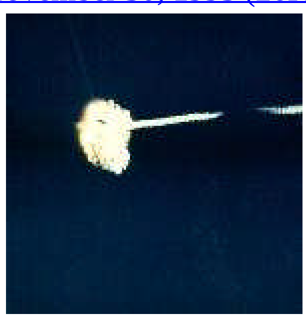
ERINT Test Flight, November 30, 1993 (24K)



ERINT Missile Launch, November 30, 1993 (26K)

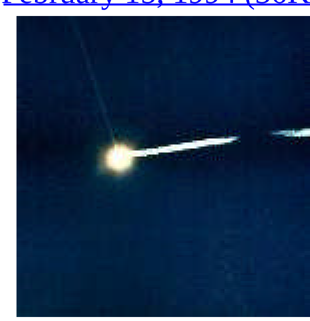


PAC-3 Launch Intercept Sequence
February 15, 1994 (36K)



PATRIOT PAC-3 ERINT White Sands
February 15, 1994 (21K)

PATRIOT PAC-3 ERINT White Sands
February 15, 1994 (19K)

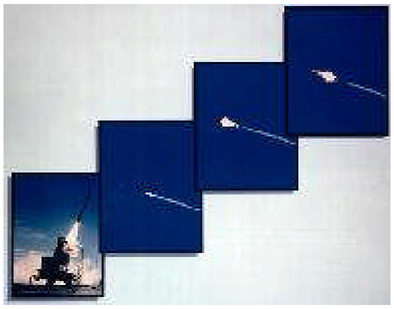


PATRIOT PAC-3 ERINT White Sands

PATRIOT PAC-3 ERINT White Sands

February 15, 1994 (23K)

February 15, 1994 (37K)



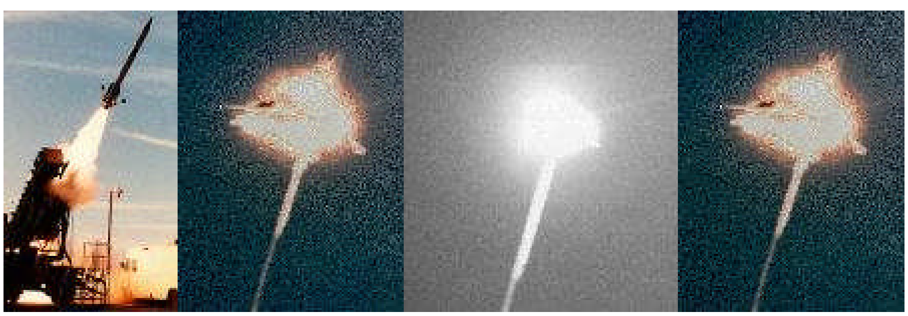
PAC-3 Launch Intercept Sequence
June 2, 1994 (27K)

PATRIOT PAC-3 ERINT White Sands
June 2, 1994 (23K)

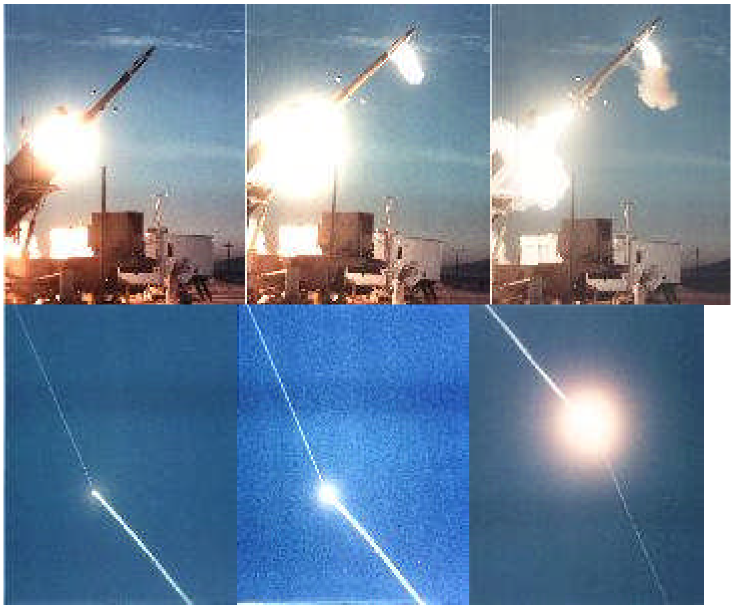
PATRIOT PAC-3 ERINT White Sands
June 2, 1994 (24K)

PATRIOT PAC-3 ERINT STORM Intercept (11K)

PATRIOT PAC-3 ERINT STORM Intercept (22K)



PAC-3 Intercept Test -- 05 February 2000

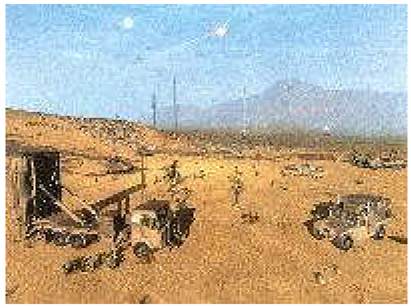


Medium Extended Air Defense System (MEADS)
Corps SAM

MEADS is a transatlantic cooperative effort between the United States, Germany, and Italy to develop an air and missile defense system that is tactically mobile and transportable. It will be capable of countering tactical ballistic missiles and air-breathing threats, including cruise missiles. MEADS will improve the limited area defense of vital assets, both civilian and military, as well as provide capability to move with and protect the maneuver forces. MEADS will provide coalition forces with a system capability that is currently not available: a weapon system that can be deployed where it is needed with the versatility to provide force and asset protection during all phases of military operations. It will be employed either in combination with other systems as part of an integrated air defense, or individually in stand-alone operations.

The Medium Extended Air Defense System (MEADS), formerly the Corps SAM program, is the only Theater Missile Defense (TMD) system under consideration to provide maneuver forces with 360 degree defense protection against the real and growing threat of short-range tactical ballistic missiles, cruise missiles, and unmanned aerial vehicles. This system is intended to provide fundamental enhancements in tactical mobility, strategic deployability, and operational capability. Key in this regard will be transportability on C-130 aircraft as a highly mobile system designed to protect our forward deployed and maneuvering forces. MEADS would replace Hawk, and some portion of Patriot. DOD plans to defer equipping three Patriot battalions with PAC-3 pending a decision on development and deployment of MEADS.

MEADS is currently in a transition phase between the Project Definition Phase (PDF) and the Design and Development Phase (D&DP). MEADS is planning to use a three year Risk Reduction Phase before entering a full D&D phase. A RFP was due to be sent out August/September 1999, in order to cover Prime contractor involvement in this phase, and to prepare for the D&D Phase. A six-month negotiation period was planned for this contract after RFP release. On 19 May 1999 the Ballistic Missile Defense Organization (BMDO) and NATO Medium Extended Air Defense System Organization (NAMEADSMO) announced the selection, by a tri-national source selection committee, of MEADS International as the prime contractor for MEADS. MEADS International is a joint venture comprised of Lockheed Martin of the United States, DaimlerChrysler Aerospace AG of Germany, and Alenia Marconi Systems of Italy. NAMEADSMO is made up of a steering committee consisting of one representative each from the U.S., Germany, Italy, and the NATO MEADS Management Agency (NAMEADSMA), located in Huntsville, Alabama.



THAAD TMD

The Theater High-Altitude Area Defense [THAAD] system would provide extended coverage for a greater diversity and dispersion of forces and the capability to protect population centers. However, the principal additional capability provided by this system is its ability to deal with longer-range theater missile threats as they begin to emerge. THAAD also reduces the number of missiles that the lower-tier systems must engage and provides a shoot-look-shoot capability--the ability to engage incoming missiles more efficiently.

THAAD is the most mature upper-tier system. The President's Budget 1997 schedule for this program had LRIP beginning in fiscal year 2003, with a FUE in fiscal year 2006. However, DOD subsequently added $690 million to this program over the FY 1998 FYDP, which moves the FUE to late fiscal year 2004. This additional funding also: (1) completes the funding for the second Engineering and Manufacturing Development (EMD) radar, (2) decreases schedule and technical risks during EMD, and (3) decreases the total acquisition cost by $457 million.

The THAAD Program was restructured in 1996, although there was a decision to keep the UOES portion of the program on track. DOD planned to be able to deploy an initial limited THAAD UOES capability in the second quarter of FY 1999 should a contingency arise. The final UOES capability would include about 40 missiles and two radars, which will be used for user testing, but which could be maintained in theater if needed.

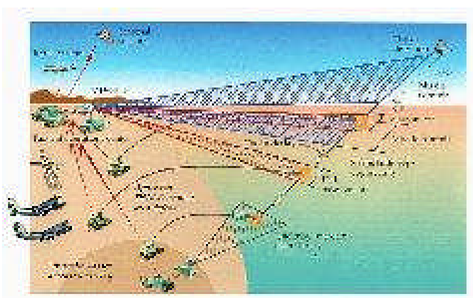
Recent testing difficulties have led to the slip of this capability from the fourth quarter of FY 1998 to the second quarter of FY 1999. THAAD faces significant system engineering challenge. The fact that recent THAAD flights have not met all their objectives, stretching out testing and delaying the start of EMD by over fifteen months, illustrates the difficulty of this task. Since the seventh THAAD test was not successful, it was necessary to reevaluate the program's schedule and content.

Studies done by the military and independent sources cited the following problems in the Theater High Altitude Area Defense (THAAD) Program: First, the program's compressed flight-test schedule did not allow for adequate ground testing, and officials could not spot problems before flight tests. The schedule also left too little time for preflight testing, postflight analysis, and corrective measures. Second, the requirement that an early prototype system be deployed quickly has diverted attention from the normal interceptor development process and resulted in interceptors that were not equipped with sufficient instruments to provide optimum test data. Third, quality assurance received too little

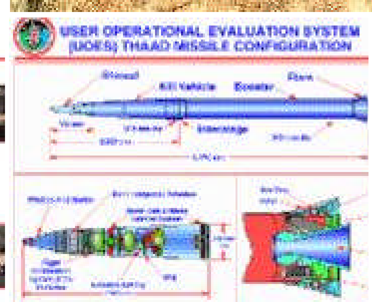
emphasis and resources during component production, resulting in unreliable components. Fourth, the contract to develop the interceptor was a cost-plus-fixed-fee contract, which placed all of the financial risk on the government and did not hold the contractor accountable for less than optimum performance.

The restructuring addressed each of these four underlying problems. However, the reliability of current flight-test interceptors remains a concern because most components were produced when the contractor's quality assurance system was inadequate. Test failures caused primarily by manufacturing defects rather than advanced technology problems have prevented the Army from demonstrating that THAAD can reliably intercept targets in all required regions.

The restructuring of the THAAD program raised the issue of what the purpose of the User Operational Evaluation System battalion at Fort Bliss should now be. Whether all or only part of the battalion would warrant deployment for contingency operations would depend on the capabilities it could provide to warfighters and the priority of the need for one or more of those capabilities. However, there would be little basis for making a deployment determination because the Defense Department does not plan to conduct an operational assessment of the User Operational Evaluation System.



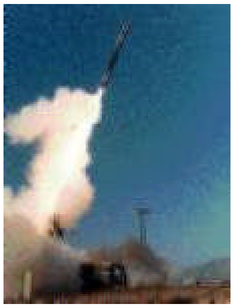




THAAD System (92K) User Operational THAAD Battery Activation

Evaluation System
THAAD Missile
Configuration (89K)

June 6, 1995 (73K)



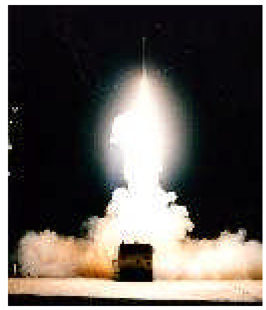
THAAD FTV-01,
April 21, 1995 (29K)

THAAD Flight 2,
July 21, 1995 (21K)

THAAD Flight 3,
October 13, 1995 (44K)

THAAD Flight 3,
October 13, 1995 (26K)

THAAD Flight 4,
December 13, 1995 (37K)



THAAD Flight Test
5, March 22, 1996 (31K)

THAAD Divert and Attitude
Control Thrusters (42K)

THAAD Launcher in the
Field
December 1995 (74K)

THAAD White Sands
Deployment
December 1995 (83K)

THAAD Launcher (79K)

THAAD Launcher White

THAAD Launcher

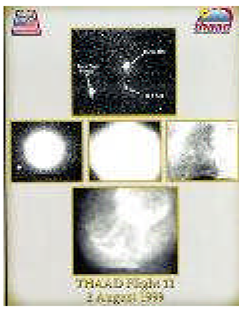
Sands (70K)

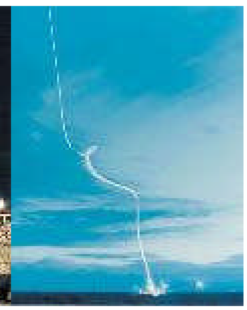


THAAD Radar (83K)

THAAD Radar Antenna Element and Electronics (61K)

THAAD Launcher





Follow-On To TOW (FOTT)

The Follow-On To TOW (FOTT) is intended to provide improved long range, lethal, anti-tank capability for systems currently equipped with the Tube-launched, Optically-tracked, Wire-guided (TOW) missile (with the exception of air platforms). Appliqué kits, including hardware and software, are being developed for the following platforms - Improved TOW Acquisition System (ITAS), Improved Bradley Acquisition System (IBAS) and Bradley A2/A2 ODS . The missile concept includes a wooden round modular design with extended shelf-life capability.

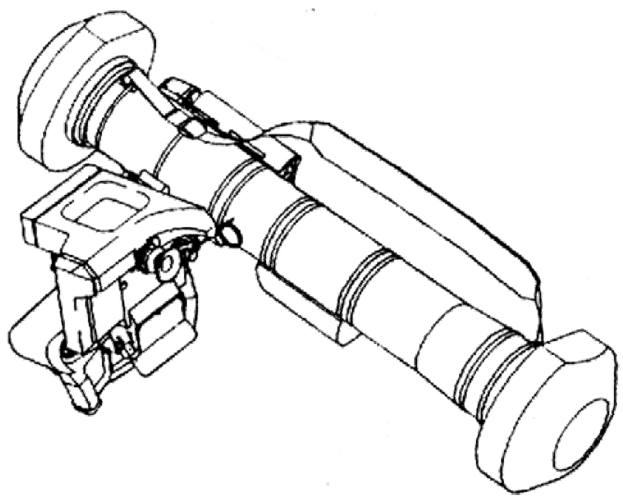
The FOTT system will be comprised of the encased FOTT missile and associated platform integration appliqué kits. Key FOTT missile requirements are: (1) compatibility with all TOW ground platforms; (2) fire and forget primary mode of operation with an alternate (semi-automatic command to line-of-sight) mode as backup; (3) increased range, lethality and platform survivability; (4) modular design for future growth and shelf-life extension; and (5) backward compatibility with TOW missiles. Future growth will be accommodated by the FOTT modular design and by transition of applicable technologies from on-going tech base programs. FOTT's precision engagement capability will enhance the Army's ability to dominate the ground maneuver battle.

The FOTT System is the next generation missile system for approximately 5,000+ existing U.S. Army Tube-Launched Optically-Tracked Wire-Guided (TOW) platforms. The Army plans to reduce developmental risks by leveraging demonstrated missile technology and to reduce development and support costs by leveraging the use of existing TOW platforms. FOTT will also take advantage of the increased range of emerging 2nd generation FLIR target acquisition systems (ITAS & IBAS). FOTT will provide improved, long-range anti-armor capability and, with its "fire-and-forget" enhancement, will improve survivability.

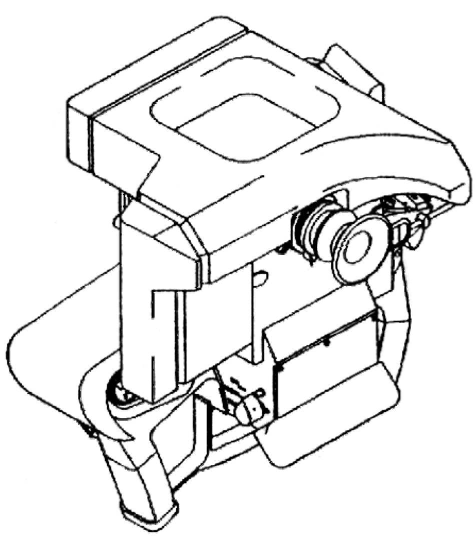
No developmental or operational testing of a FOTT configured system has been performed to date. IOT&E is planned for FY 2005. ITAS has completed EMD testing and is presently conducting PQT testing. ITAS fielding is planned in May 1998. IBAS is currently nearing the completion of EMD and approval has been received for LRIP. Operational, live-fire, and developmental test strategies are near completion for incorporation in the TEMP to support milestone II (3QFY98) and subsequent contract selection.

Javelin Antitank Missile

The Javelin is a manportable, fire-and-forget, antitank missile employed by dismounted infantry to defeat current and future threat armored combat vehicles. Javelin is intended to replace the Dragon system in the Army and the Marine Corps. JAVELIN has significant improvements over DRAGON. The Javelin's range of approximately 2,500 meters is more than twice that of its predecessor, the Dragon. The Javelin has secondary capabilities against helicopters and ground-fighting positions. It is equipped with an imaging infrared (I2R) system and a fire-and-forget guided missile. The Javelin's normal engagement mode is top-attack to penetrate the tank's most vulnerable armor. It also has a direct-attack capability to engage targets with overhead cover or in bunkers. Its "soft launch" allows employment from within buildings and enclosed fighting positions. The soft launch signature limits the gunner's exposure to the enemy, thus increasing survivability. JAVELIN is also much more lethal than DRAGON. It has a top attack dual warhead capability which can defeat all known enemy armor systems.

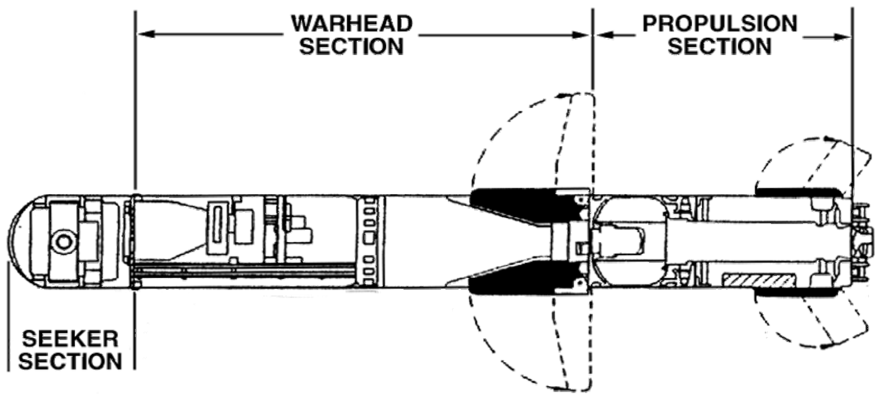


The Javelin is a tactical precision engagement system that enhances the Army's ability to dominate the ground maneuver battle. The Javelin's impact on scout capabilities will be significant. It will allow dismounted scouts to execute reconnaissance and combat patrols with a relatively lightweight thermal sight. It will also give dismounted patrols the capability of dealing with unexpected armored vehicle threats. (Scouts, however, will not use the Javelin to seek out and destroy enemy armor in offensive operations.)



The Javelin consists of a missile in a disposable launch tube and a reusable Command Launch Unit (CLU) with a trigger mechanism and the integrated day/night sighting device for surveillance, and target acquisition and built-in test capabilities and associated electronics. The CLU, powered by a disposable battery, provides the capability for battlefield surveillance, target acquisition, missile launch, and damage assessment. The Javelin's CLU provides battlefield

surveillance and target acquisition capabilities. The Javelin night vision sight (NVS) is a passive I2R system. The NVS enables observation of things that are not normally visible to the human eye. It receives and measures IR light emitted by the environment. The NVS converts the IR light into an image for the gunner. The IR image also allows the gunner to identify enemy armor targets, his first priority to engage and destroy. Javelin gunners must identify battlefield combatants at night based on the images seen in the NVS. The gunners must distinguish friends from foes to preclude fratricide. The Night Vision Laboratory has developed materials to train Javelin gunners to identify friends and targets based on their IR images. The round consists of a disposable launch tube assembly, battery coolant unit (BCU), and the missile. Missile range is 2000 meters. The missile locks on to the target before launch using an infrared focal plane array and on-board processing, which also maintains target track and guides the missile to the target after launch. A full-up system weighs 49.5 pounds.



Weight:	28 kg
Length:	1.76 meters
Range:	2000 m (max) 75 m (min)
Warhead Type:	Heat
Warhead Weight:	8.4 kg
Armor Penetration:	600+ mm
Launching Platforms:	man portable crew of 2

A January 1978 Antiarmor Mission Need Statement identified the deficiencies of the Army's current manportable antiarmor weapon, the Dragon. The Joint Service Operational Requirements document for the Javelin was approved in 1986 and amended in 1988. The contract for Javelin EMD was awarded in 1989. The IOT&E, which was completed in December 1993, resulted in the conclusion that the Javelin was effective, but required further assessment for suitability, necessitating follow-on testing in the form of a Limited User Test (LUT) beginning in April 1996. LRIP was approved by the DAB in July 1994. There are several Javelin enhanced producibility program (EPP) changes that are being incorporated in the system to enhance producibility and reduce cost.

The LUT consisted of three events: Situational Tactical Exercises, which were limited force-on-force engagements; Live Fire Exercises, which consisted of six explosive warhead shots; and Multiple Integrated Laser Engagement System Pairing and Operational Lock-on Trials, which compared the ability of the Javelin field tactical trainer to replicate the tactical system. Missile reliability problems caused a temporary halt in the firing program. Three failed launch situations occurred early on, requiring fixes before the Army could complete the LUT in June 1996.

LFT&E started in November 1995 and was completed in October 1996. It consisted of three progressive phases that challenged the Javelin against current and emerging tank threats. Phase A consisted of a large series of shots to determine the missile's capability to penetrate rolled homogeneous armor and to more fully understand its ability to create behind-armor debris immediately upon penetration. Phase B tested the missile's ability to penetrate shotline targets representing an advanced threat tank, and Phase C was the full scale, full-up LFT&E phase.

The full rate production, Milestone III, decision was made May 13, 1997. In March and April 1997, and in accordance with the approved TEMP (March 12, 1997), a Confirmatory Test (CT) was conducted at Fort Benning, Georgia, to confirm that a Javelin Enhanced Producibility Program (EPP) had not adversely affected the effectiveness and suitability of the system. The final phase of the Javelin LFT was completed in early 1997. The required report to Congress on Javelin's lethality was included in the BLRIP report (May 1997). DOT&E approved an LFT&E strategy for a potential warhead improvement program to keep pace with expected advances in threat heavy armor, and to improve lethality in the direct-fire mode against currently fielded threat tanks.

There are two requirements for missile reliability that remain under test. At Milestone III, missile reliability was to be 0.82 and at System Maturity (MS III plus three years), 0.92. Developmental testing continues on the LRIP and EPP versions of the command launch unit and missile.

A series of Operational and Live Fire Tests were adequate to determine the system's operational effectiveness, suitability and lethality. The final OT&E assessment is based on the complete evaluation period, including the 1993 IOT&E, 1996 LUT, 1997 CT, and LFT&E. As outlined in the BLRIP (April 1997) to Congress, the Javelin Anti-Tank Weapons System was judged to be operationally effective, suitable and lethal (BLRIP report is included in a separately bound annex of the classified version of this annual report). To date, the LRIP missile has exceeded the Milestone III reliability requirement but has yet to meet the reliability requirement for system maturity. EPP missiles have been fired and are to be scored to determine their reliability.

A key point in this era of acquisition streamlining is that it took live testing to discover the following findings, something that simulation would not have been able to accomplish.

Requirements should be formally reviewed periodically. Javelin requirements were written in 1988 and never updated. One requirement, the probability of kill given an engagement opportunity (PK(EO))---did not take into account selected human factors and new technology that the contractor would include in the Javelin. By the time one applied all of the contributing factors into the calculation of the PK(EO), the result was much lower than the requirement but good enough to determine the system effective given the

newly understood human factors and the availability/reliability factors of system components.

DOT&E early involvement facilitates PM decisions to ensure adequate testing. Three operational tests would not have been conducted without DOT&E oversight: (1) A Limited User's Test which resulted in a number of improvements, especially in reliability and availability. (2) A Multiple Parings and Operational Lock-on Test which enabled a comparison of the entire end-to-end engagement sequence between the tactical system and the Field Tactical Trainer (FTT) that provided the appropriate insights to adequately measure how well the FTT met its requirement to replicate the tactical system. (3) A Confirmatory Test which provided performance of the Enhanced Producibility Program version of the missile early enough to impact on the MS III decision and reduce the scope of follow-on tests.

Tactics and doctrine can be developed initially by simulation but live experience is necessary to mold them into viable tactics, techniques and procedures (TTPs). One example: The ability to distinguish friend or foe becomes very difficult at greater ranges. Situational awareness and command and control measures were not adequate to preclude firing on "friendlies." The "man-in-the-loop" variable provided the insights that simulation could not yield.

Test-Fix-Test is an efficient and effective methodology that provides numerous timely changes to system design. There were several changes made to the Javelin that resulted from either Operational or Live Fire Testing. One of the more notable examples is the Power Distribution Assembly (PDA). During Phase A of the LFT, it was discovered that the main charge in the warhead in the tandem configuration was achieving about 100mm less rolled homogeneous armor penetration than had been expected. Analysis revealed that the deficiency was caused by a combination of a slightly thicker PDA bulkhead in the EPP design coupled with a second production source for the main charge liner that had used a slightly different manufacture process. The thickness of the PDA bulkhead was reduced and the expected penetration was realized.

Always anticipate updating models and simulations after live testing. LFT&E preshot predictions overstated the penetration of the Javelin warhead against targets protected by Explosive Reactive Armor. The cause was the overestimation of two aspects of tandem warhead performance. After live testing, appropriate corrections were made to input data of the penetration model before Javelin's lethality were computed.

Line-of-Sight Antitank Missile (LOSAT)

LOSAT is a dedicated antitank weapon system providing a high rate of extremely lethal fire at ranges exceeding tank main gun range, making it capable of defeating any known or projected armor system. The system utilizes a Heavy High Mobility Multipurpose Wheeled Vehicle (HMMWV) heavy chassis, hypervelocity kinetic energy missiles (KEM), a second generation forward-looking infrared (FLIR/TV) acquisition sensor and has a crew of two. The LOSAT System carries four ready missiles via two two-pack containers. LOSAT can operate autonomously or with other systems using its digitized Command and Control capability. Range of the LOSAT missile is greater than 4 km.

The missile accelerates to 5000 feet per second, flies to maximum range in less than four seconds and delivers five times the kinetic energy of current tank rounds. The fire control system allows the gunner/commander to acquire and auto-track up to three targets. Once a launch consent is issued, the system automatically initializes and guides the missiles to the targets in a sequential manner. It is deployable on C-130 through C-5 aircraft including airdrop from the C-130.

The LOSAT program started an Army ACAT I system with oversight by DOT&E. In 1992, analysis by the Army caused the program to be reduced to a Technology Demonstration. The program was upgraded by the JROC to an Advanced Concept Technology Demonstration (ACTD) (4QFY97). Initially, LOSAT was to be mounted on an extended length Bradley Fighting Vehicle. As a Technology Demonstration it was to be mounted on an Armored Gun System (AGS) chassis but when the AGS program was canceled, LOSAT was reconfigured to a HMMWV chassis. Developmental testing has been conducted using the fire control system to direct the kinetic energy missile at tank targets.

Testing at White Sands Missile Range, NM examined the launch effects of the LOSAT on an expanded-capacity HMMWV. Under developmental test conditions, the missile is capable of defeating any known tank it hits. Test firing of the LOSAT missile in a non-tactical configuration on top of a HMMWV has shown all launch effects to fall within the Army's acceptable ranges for human factor limits. Data gathered were extensive both inside and outside of the vehicle. Measurements were made of shock and g-load, on crash test dummies, and flash, toxic gases, pressure, and sound in and outside the vehicle. Numerous operational performance issues must be addressed in future testing – either within the ACTD or in subsequent formal OT&E covered by a TEMP.

M-47 DRAGON Anti-Tank Guided Missile

The complete system consists of the launcher, the tracker and the missile, which is installed in the launcher during final assembly and received by the Army in a ready to fire condition. The launch tube serves as the storage and carrying case for the missile. The night tracker operates in the thermal energy range.

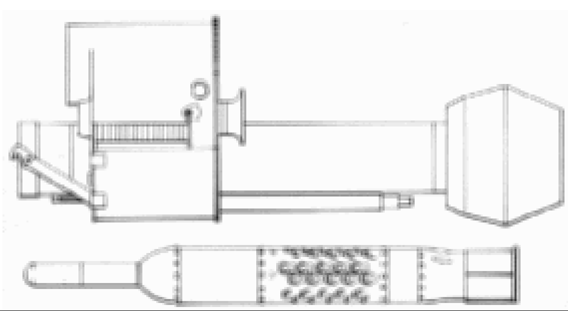
The Dragon is a medium range, wire-guided (guidance of the missile to target is controlled by a thin wire), line-of-sight anti-tank/assault missile weapon capable of defeating armored vehicles, fortified bunkers, concrete gun emplacements and other hard targets. The system contains a launcher, tracker and missile. The launcher is an expendable, smooth bore, fiberglass tube with tracker and support bipod, battery, sling and front and back shock absorbers. It is designed to be carried and fired by an individual gunner.

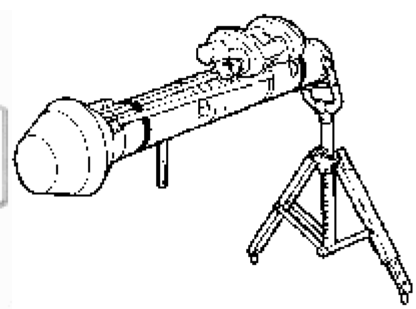
The warhead power of Dragon makes it possible for a single soldier to defeat armored vehicles, fortified bunkers, concrete gun emplacements, or other hard targets. The Dragon was developed for the US Army in 1970. It uses a cone-shaped charge for maximum penetration. The wire guidance allows the gunner to hit his target by keeping the cross hairs on the target until detonation. The missile is installed in the launcher during final assembly by the manufacturer and is received in a ready-to-fire condition. The launch tube serves as the storage and carrying case for the missile. The launcher consists of a smoothbore fiberglass tube, breech/gas generator, tracker and support, bipod, battery, sling, and forward and aft shock absorbers. Non-integral day and night sights are required to utilize the Dragon. The launcher is expendable. The day and night tracker sights can be reused.

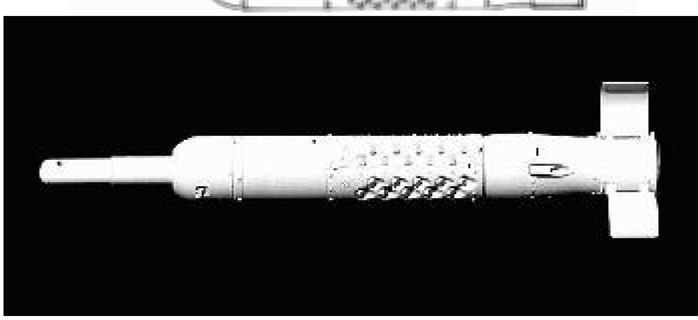
The US Dragon was redesigned twice, and evolved into the present Superdragon by 1990. The first-generation Dragon, a 1000-meter system requiring 11.2 seconds flight-to-target time, was developed for the US Army and fielded in 1970. A product improvement program (PIP) was initiated by the Marine Corps in 1985 and managed by NSWC Dahlgren. The PIP, designated Dragon II, was designed to increase warhead penetration effectiveness by 85%. The Dragon II missile is actually a retrofit of warheads to the first generation missiles already in the Marine Corps inventory. The current version is capable of penetrating 18 inches of armor at a maximum effective range of 1,500 meters. The Dragon saw limited use in Operation Desert Storm, and Iraq is believed to have captured Dragons from Iran. The Dragon guidance system has been criticized for requiring excessive gunner control, inaccuracy in general, and some early versions suffered recurrent rocket thruster failure.
Manufactured by McDonnell Douglas, the Dragon was adopted by the US Army and Marine Corps and is used by at least 10 other countries. The Army has 7,000 systems in its inventory with approximately 33,000 Dragon missiles. The Marine Corps has 17,000 Dragon missiles in its inventory

Specifications

Guidance:	Semi-automatic, wire
Warhead	High Explosive Anti-tank
Warhead diameter:	ca 140 mm
Launch unit weight:	6.9 kg
Launching Platforms	Manpack (crew of 2)
Missile weight:	10.07 kg
Warhead weight	5.4 kg
Missile length:	852 mm
Max. effective range:	1000-1500 meters
Range	75 meters (minimum)
Max. velocity:	ca 200 m/sec
Penetration of armor:	400+ / 500 mm
Manufacturer:	McDonnell Douglas Aerospace, USA







Dragon guided missile.






M136 AT4

The M136 AT4 is the Army's primary light anti-tank weapon. The M136 AT4 is a recoilless rifle used primarily by Infantry Forces for engagement and defeat of light armor. The recoilless rifle design permits accurate delivery of an 84mm High Explosive Anti-Armor warhead, with negligible recoil. The M136 AT4 is a lightweight, self-contained, antiarmor weapon consisting of a free-flight, fin-stabilized, rocket-type cartridge packed in an expendable, one-piece, fiberglass-wrapped tube. The M136 AT4 is man-portable and is fired from the right shoulder only. The launcher is watertight for ease of transportation and storage. Unlike the M72-series LAW, the M136 AT4 launcher need not be extended before firing. Though the M136 AT4 can be employed in limited visibility, the firer must be able to see and identify the target and estimate the range to it. Subsequent to the initial fielding of the weapon, a reusable night sight bracket was developed and fielded. It permits utilization of standard night vision equipment. The system's tactical engagement range is 250 meters and has been used in multiple combat situations. The round of ammunition is self-contained in a disposable launch tube. The system weighs 15 pounds and can be utilized effectively with minimal training.

TECHNICAL DATA

The following data apply to the M136 AT4:
Primary function: Light anti-armor weapon
Manufacturer: FFV Ordnance, Sweden and Alliant Techsystems

Launcher.
Length..................... 1,020 mm (40 inches)
Weight (Complete System) .. 6.7 kg (14.8 pounds)
Rear Sight................. Range indicator, graduated in 50-meter increments

Rocket.
Caliber .... 84 mm
Muzzle Velocity............ 290 mps (950 fps)
Length .... 460 mm (18 inches)
Weight..................... 1.8 kg (4 pounds)
Minimum Range Training .... 30 meters (100 feet)
Combat .... 10 meters (33 feet)
Arming.................. 10 meters (33 feet)
Maximum Range .... 2,100 meters (6,890 feet)
Maximum Effective Range ... 300 meters (985 feet)
Penetration: 400 mm of rolled homogenous armor
Time of Flight (to 250 meters): less than 1 second
Muzzle velocity: 950 feet (285 meters) per second
Operating temperature: -104 to +140° F (-40 to +60°C)

Ammunition: Rocket with shaped charge warhead
Unit Replacement Cost: $1,480.64

The M136 AT4's warhead has excellent penetration ability and lethal after-armor effects. The extremely destructive, 440 gram shaped-charge explosive penetrates more than 14 inches (35.6 cm) of armor.

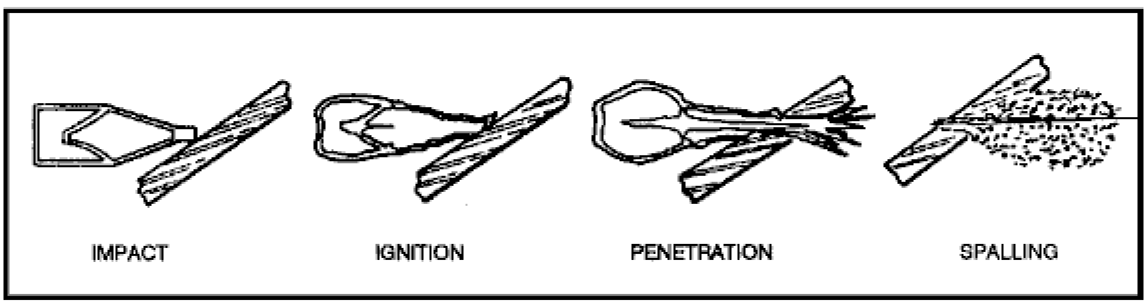


Figure 3-3. Effects of M136 AT4 warhead.

- (1) Impact. The nose cone crushes; the impact sensor activates the fuze.
- (2) Ignition. The piezoelectric fuze element activates the electric detonator. The booster detonates, initiating the main charge.
- (3) Penetration. The main charge fires and forces the warhead body liner into a directional gas jet that penetrates armor plate.
- (4) After-armor effects (spalling). The projectile fragments and incendiary effects produce blinding light and destroy the interior of the target.

M136 AT4 launchers are marked with color-coded bands). A black with yellow band indicates an HE antiarmor round (early models had a solid black band). A gold or yellow band indicates a field handling trainer; no band indicates an M287 9-mm tracer bullet trainer

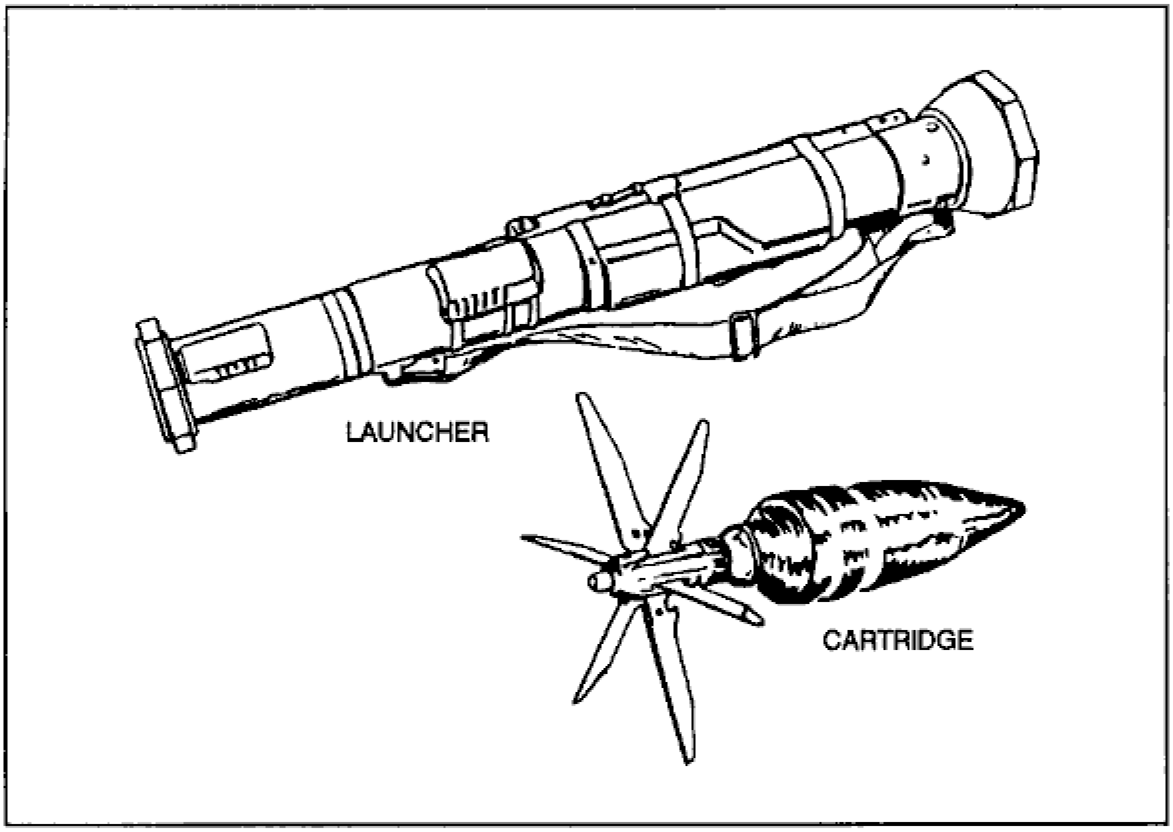


Figure 3-1. Launcher and HEAT cartridge.

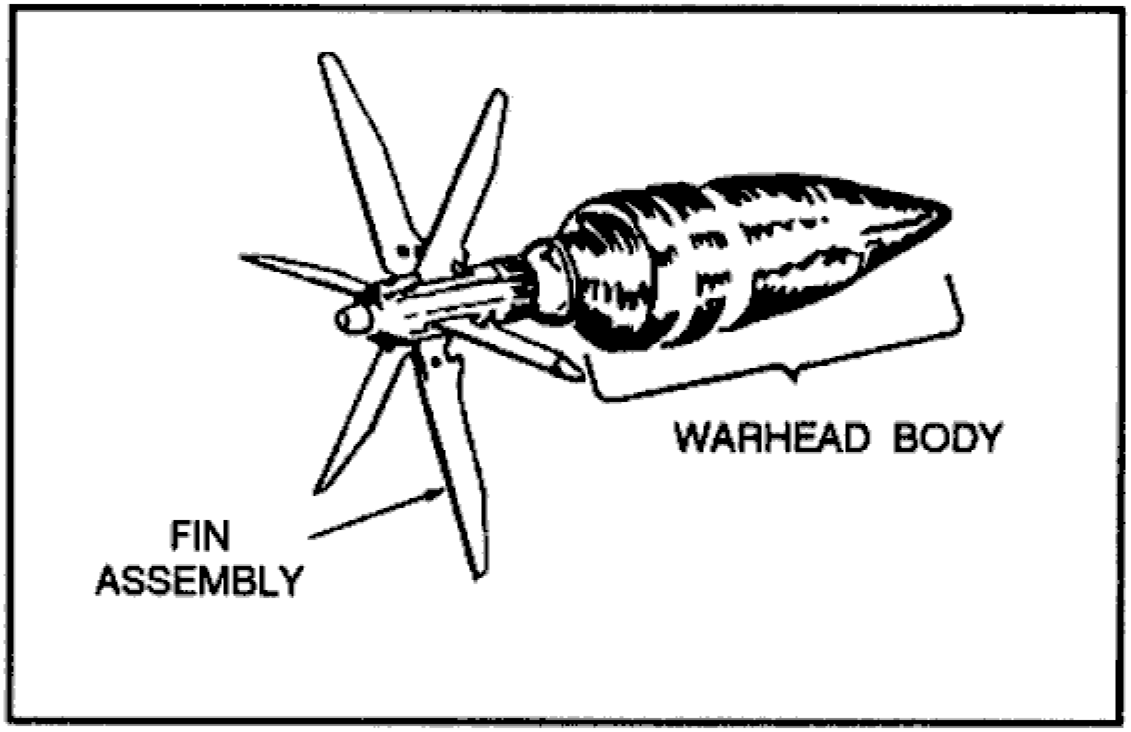


Figure 3-2. The 84-mm HEAT cartridge.

M-220 Tube-launched, Optically tracked, Wire-guided missile (TOW)

The TOW anti-tank missile of Iran-Contra fame was introduced for service in the US Army in 1970. Current versions are capable of penetrating more than 30 inches of armor, or "any 1990s tank," at a maximum range of more than 3,000 meters. It can be fired by infantrymen using a tripod, as well from vehicles and helicopters, and can launch 3 missiles in 90 seconds. It is primarily used in antitank warfare, and is a command to line of sight, wire-guided weapon. TOW is used to engage and destroy enemy armored vehicles, primarily tanks. Secondary mission is to destroy other point targets such as non-armored vehicles, crew-served weapons and launchers. This system is designed to attack and defeat tanks and other armored vehicles. The system will operate in all weather conditions and on the "dirty" battlefield.
The basic TOW Weapon System was fielded in 1970. Manufactured by Hughes Aircraft Company, the TOW is the most widely distributed anti-tank guided missile in the world with over 500,000 built and in service in the U.S. and 36 other countries. The TOW has extensive combat experience in Vietnam and the Middle East. Iran may have obtained 1,750 or more TOWs and used TOWs against Iraqi tanks in the 1980s. The TOW 2 launcher is the most recent launcher upgrade. It is compatible with all TOW missiles. The TOW 2 Weapon System is composed of a reusable launcher, a missile guidance set, and sight system. The system can be tripod mounted. However because it is heavy, it is generally employed from the HMMWV. The missile has a 20-year maintenance-free storage life. All versions of the TOW missile can be fired from the current launcher.

The TOW is a crew portable, vehicle-mounted, heavy anitarmor weapon system consisting of a launcher and one of five versions of the TOW missile. It is designed to defeat armored vehicles and other targets such as field fortifications from ranges up to 3,750 meters. After firing the missile, the gunner must keep the cross hairs of the sight centered on the target to ensure a hit. The system will operate in all weather conditions in which the gunner can see a target throughout the missile flight by using either a day or night sight.

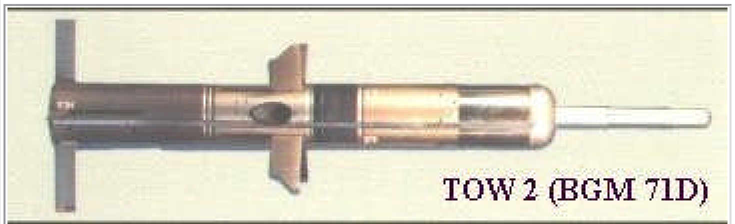
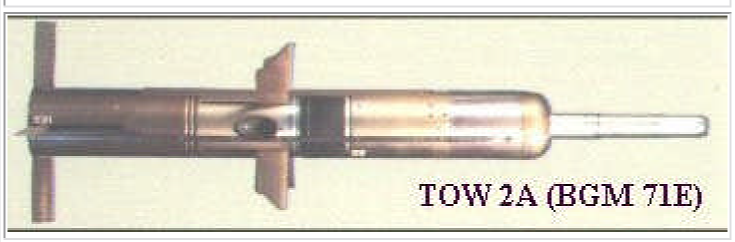
The TOW Sight Improvement Program (TSIP) effort began in 199 However, on 15 October 1991 The Secretary of the Army cancelled the TSIP because of declining budget & funding issues. The Assistant Secretary of the Army for Research, Development and Acquisition directed the PEO, Tactical Missiles to coordinate the development of an affordable alternative. The latter effort subsequently became known as the Improved Target Acquisition System (ITAS) being developed for the Army's light forces.

The TOW Improved Target Acquisition System (ITAS) is a materiel change to the The ITAS is a material change to the current TOW2 ground launcher and M966 HMMWV TOW2 acquisition and fire control subsystems for first-to-deploy light forces. ITAS aides in firing all versions of TOW and builds the bridge to TOW F&F. The TOW tripod and launch tube remain unchanged. ITAS significantly increases target acquisition and engagement ranges, while retaining the capability to fire all configurations of the TOW missile. ITAS uses a second-generation forward-looking infrared system, digital components, and an eyesafe laser range finder. ITAS has an improved design with BIT/ BITES for increased maintainability and reduced logistics requirements. It also features an improved man-machine interface that improves system engagement performance. The ITAS modification kit consists of an integrated (Day/ Night Sight with Laser Rangefinder) Target Acquisition Subsystem (TAS), Fire Control Subsystem (FCS), Battery Power Source (BPS), and Modified Traversing Unit (TU). The ITAS will operate from the High Mobility Multi- Purpose Wheeled Vehicle (HMMWV) and the dismount tripod platform. The ITAS will be fielded at battalion level, replacing TOW 2 in light infantry units. The TOW Improved Target Acquisition System low- rate initial production (LRIP) I contract was awarded September 30, 1996, with a production quantity of twenty- five units. LRIP II was awarded March 1998 for a quantity of seventy-three systems for the 1st BDE Fielding in September 1999. First unit equipped (FUE) was conducted in September 1998.

The TOW system is used on the HMMWV, the M151 jeep, the armored personnel carrier, the Bradley Fighting Vehicle (BFV) COBRA helicopters, the ITV, and the US Marine Corps light armored vehicle.

Considerable improvements have been made to the missile since 1970. There are six missiles available for the TOW. Three of the five TOW missile versions--Basic TOW, Improved TOW and TOW 2--are no longer being produced for US forces. However, these versions are still used by 40 allied countries.

	**BGM-71A Basic TOW** The original TOW missile had a diameter of 5 inches and a range of 3000 meters.
	BGM-71A-1 Basic TOW extended range -
	**BGM-71C Improved TOW (ITOW)** The Improved TOW (ITOW) was delivered in 1982. This missile has a 5-inch diameter warhead, and includes an extended probe for greater

	standoff and penetration. An enhanced flight motor was included in the ITOW, increasing the missile's range to 3750 meters.
	**BGM-71D TOW 2**The TOW 2 series of improvements includes TOW 2 Hardware, TOW 2 Missile. The TOW 2 [and TOW 2A] have an improved propellant in the flight motors, and the guidance links have been hardened with a thermal beacon which improves operations in dust, smoke, and other obscurants. The thermal beacon is compatible with aircraft with the C-NITE system. The TOW 2 Hardware improvements included a thermal beacon guidance system enabling the gunner to more easily track a target at night and numerous improvements to the Missile Guidance System (MGS). The TOW 2 Missile has a 6-inch diameter warhead and the extended probe first introduced with ITOW.
	**BGM-71E TOW 2A** In the late 1980s, the prime contractor for the TOW weapon system began producing the TOW 2A which gives the capability to defeat reactive armor.
	BGM-71F TOW 2B The TOW 2B is the newest version of the TOW missile which will provide additional capability against future armored threats, starting production as an engineering change proposal to the FY 1990 production contract. The TOW 2B Missile incorporates new fly-over,

	shoot-down technology. The TOW 2B entered production in late 1991. The TOW 2B was designed to attack targets from the top. The missile's trajectory places the missile slightly above the target when its two warheads explode downward.
	TOW Fire-and-Forget (TOW F&F) The next generation heavy antitank missile that will replace the current TOW series missiles. It is employed either mounted or dismounted from the TOW launcher. Tactical employment will remain the same as the current TOW with adjustments made for TOW F&F’s characteristics. TOW F&F’s primary mode of target engagement is fire-and-forget. It will have a secondary mode of attack that together with the fire-and-forget mode will enable the operator to hit any target acquired within range of the missile. First unit equipped is FY05 pending future funding of the program.

In May 1972, US soldiers initially used the TOW in combat during the Vietnam War. This was the very first time that American troops had ever fired an American-made missile under wartime conditions. The system has also seen action in various clashes between Israel and Syria as well as during the Iran/Iraq war. In Saudi Arabia the system was represented by [the HMMWV] with the light forces, the Bradley Fighting Vehicle with the heavy forces, Improved TOW Vehicle with some of the forces, and the Cobra-mounted version.

The TOW was one of the earliest missile systems to arrive in SWA because of the large Iraqi armored threat. It was deployed with some of the first units in Saudi: the 82nd Airborne Division, the 24th Mechanized Division and the 101st Airborne Division. Thousands of missiles and hundreds of launchers were used during Operation Desert Storm. Forces of other countries, including Saudi Arabia, also had TOW at their disposal. Despite early reports of the problems being experienced by U.S. Army and Marine Corps units in hitting targets during live-fire exercises because soldiers lacked experience firing the weapon as well as Iraqi use of 'dazzlers' intended to interfere with the guidance of Army TOW missiles and other antitank missiles," the TOW during Operation Desert Storm was a primary killer of Iraqi tanks, armored personnel carriers,and other vehicles.

Before the start of the coalition air campaign in January 1991, Army and Marine Corps planners noted a trend of improvement as more and more units [had] the opportunity to practice firing the TOW. The Iraqi use of dazzlers also proved to be of little concern to coalition commanders. The purpose of the dazzler is to confuse the missile guidance system so it loses track of the missile. It's a well known technology that does not work against the TOWs used in Southwest Asia. There were no reports since the war that any of these were effective in any way against TOWs.
Before the start of the actual ground offensive, US Marine units successfully employed the TOW against various Iraqi targets. On 18 January 1991, newspapers reported that US Marine Corps AH-1T Cobra helicopter gunships destroyed an Iraqi command post following Iraq's sporadic shelling of the Khafji area near the Saudi-Kuwaiti border. Four Cobra gunships destroyed a building used as an Iraqi command post with TOW missiles. Accounts told by Gulf War veterans who witnessed the TOW in action during the fighting revealed several instances where TOWs did things that surprised the engineers who designed them more than the soldiers who fired them. TOW missiles proved to be a determining factor in the first ground engagement of Operation Desert Storm. During the Battle of Khafji, which took place before the start of the actual ground offensive, the TOW demonstrated a pretty unique ability: the Saudis fought Iraqi tanks with TOW missiles and drove them out of the city. At one point in the battle, the Saudis saw Iraqi soldiers on top of a water tower. Not wishing to blow up the tower, the Saudis fired a TOW, blew the ladder off the tower and left the Iraqis stranded until the end of the battle." The lethality of the TOW missile was proven beyond doubt during the 100-hour ground campaign when one of the antitank munitions fired by US troops went right through the tank it was aimed at and penetrated another tank parked next to it. Another TOW went through a six foot dirt berm and knocked out an Iraqi armored personnel carrier on the otherside. In both instances, the TOW performed a feat which it supposedly was incapable of accomplishing.
Primary function: Guided missile weapon system.
Manufacturer: Hughes (missiles); Hughes and Kollsman (night sights); Electro Design Mfg. (launchers)
Size:
TOW 2A Missile:
Diameter: 5.87 inches (14.91 cm)
Length: 50.40 inches (128.02 cm)
TOW 2B Missile:
Diameter: 5.8 inches (14.9 centimeters)
Length: 48.0 inches (121.9 centimeters)
Warhead weight 12.4 kg **Maximum effective range**: 2.33 miles (3.75 kilometers)
Armor penetration: T-80 + / 800+ mm [>700 mm]
Time of flight to maximum effective range:
2A: 20 seconds
2B: 21 seconds
Weight:
Launcher w/TOW 2 Mods: 204.6 pounds (92.89 kilograms)
Missile Guidance Set: 52.8 pounds (23.97 kilograms)
TOW 2 Missile: 47.4 pounds (21.52 kilograms)

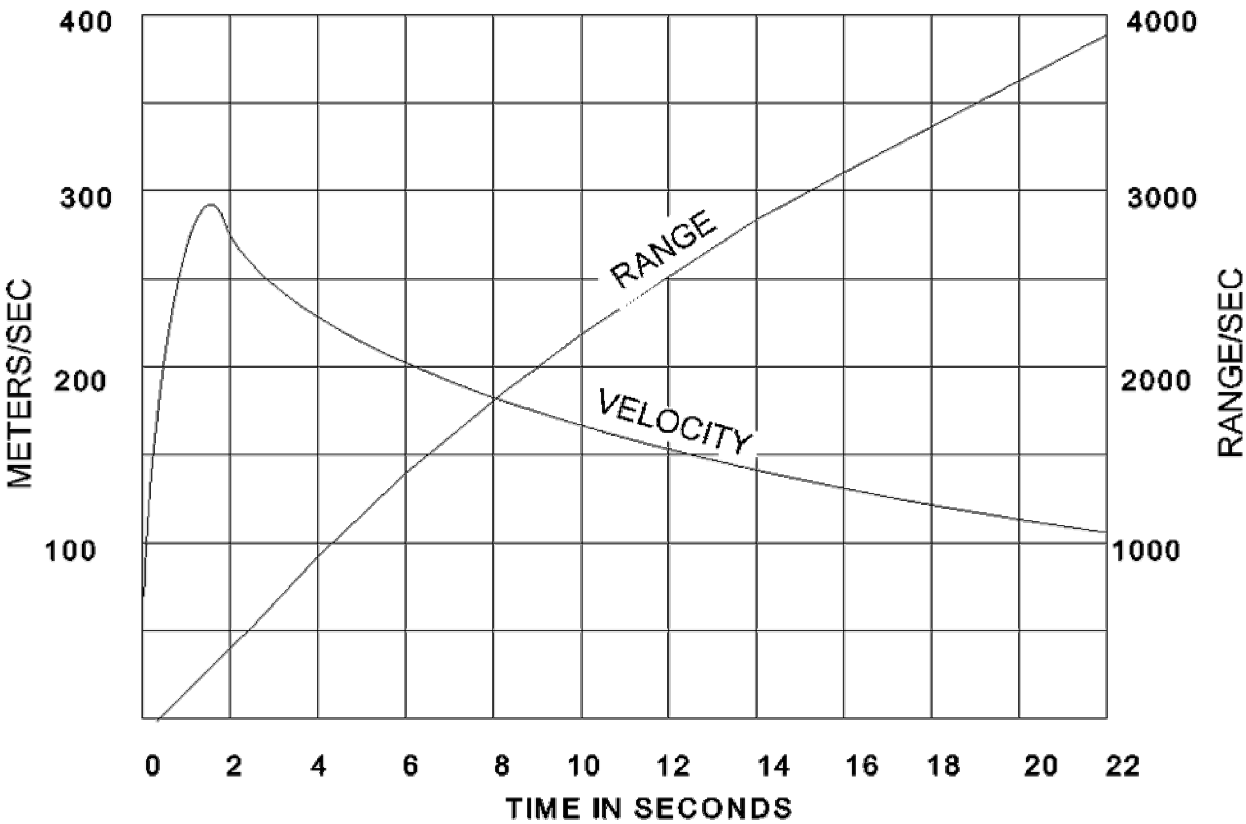
TOW 2A Missile: 49.9 pounds (22.65 kilograms)
TOW 2B Missile: 49.8 pounds (22.60 kilograms)
Introduction date: 1970
Unit Replacement Cost: $180,000

Launching Platforms	Man portable crew of 4 HMMWV M2/M3 Bradley Fighting Vehicle

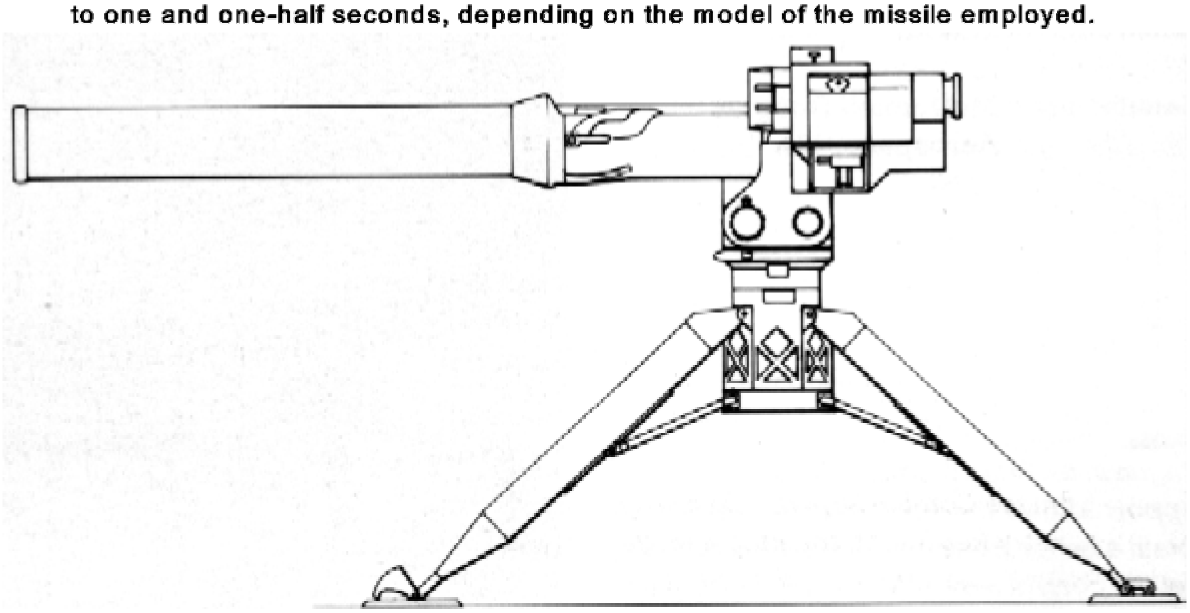
Marine Corps Inventory: TOW launchers - 1247

Characteristics of the TOW missile family

CHARACTERISTICS	BASIC TOW	I-TOW	TOW 2	TOW 2A	TOW 2B
Missile weight (lb)	41.5	42	47.3	49.9	49.8
Weight in container (lb)	56.3	56.5	61.8	64	64
Prelaunch length (in)	45.8	45.8	45.9	45.9	46
Standoff probe (in)	NA	14.6	17.4	17.4	NA
Max velocity (fps/mps)	981/299	970/296	1079/329	1079/ 329	1010/309
Warhead diameter (in)	5	5	6	5	5(2x)
Explosive filler (lb)	5.4	4.6	6.9	6.9	-
Max range (m)	3000	3750	3750	3750	3750



TOW velocity, time, and range profile values are approximate. Time of flight varies one to one and one-half seconds, depending on the model of the missile employed.




ARMY

M39 Army Tactical Missile System (Army TACMS)

The Army Tactical Missile System (Army TACMS) is a family of long-range, near all-weather guided missiles fired from the Multiple Launch Rocket System (MLRS) M270 launcher and deployed within the ammunition loads of corps MLRS

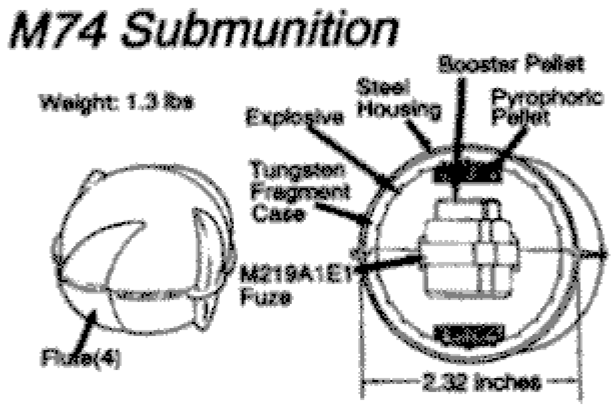
battalions. The Army TACMS provides the joint task force (JTF) and corps commanders an operational fires capability for precision engagement of the enemy throughout the depth of the battlefield beyond the range of currently fielded cannons and rockets. It delays disrupts, neutralizes or destroys high payoff targets such as combat maneuver units, surface to surface missile units, air defense units, command/control/ communications sites and helicopter forward area rearming/refueling points. The Block IA is an upgrade intended to double the range of the current Army TACMS Block I missile. Army TACMS Block IA will dispense M74 Anti-Personnel, Anti-Materiel (APAM) bomblets, as does the Block I. The Army TACMS Block IA's ability to engage the enemy at extended ranges will reinforce the dominant maneuver force by helping the JTF commander shape the battlespace.

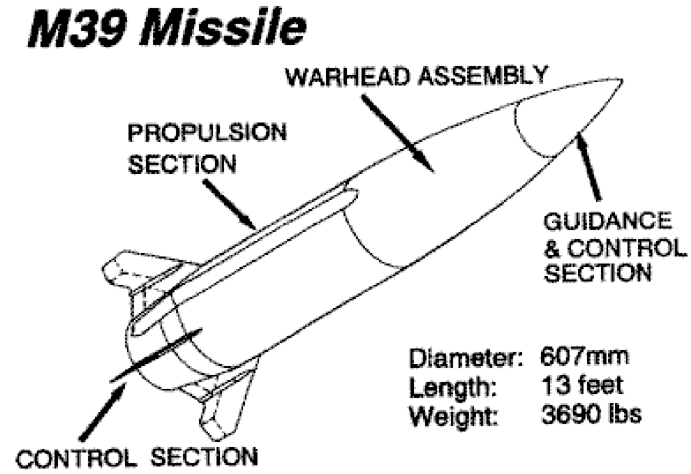
Army ACAT IC Program

800 systems
Total program cost (TY$) $658.6M
Average unit cost (TY$) $0.82M
Full-rate Production 2QFY98

Prime Contractor

Lockheed Martin Vought Systems





Guidance and Control Section (GCS). The GCS provides all navigation, guidance, autopilot, and internal communications functions for the Army TACMS missile while in flight and for all ground operations. Continuous determination of position, attitude, and motion are provided by the inertial sensors, associated electronics, and software processing. Guidance and autopilot functions are provided by software processing within the GCS computer. All communications, both internal and external to the missile (missile to launcher and/or ground support equipment), are provided by the GCS electronics and software. This includes communications with the M270 FCS electronics for launch control, the ground support equipment for maintenance, and the control system electronics unit (CSEU) for missile fin actuator control.

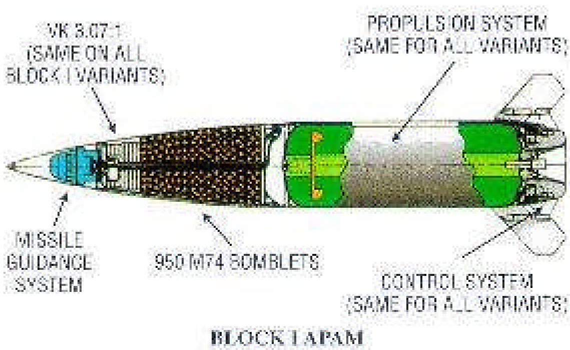
Propulsion Section. The solid rocket motor furnishes the energy necessary to launch the missile and sustain missile flight for a sufficient time to meet Army TACMS altitude and range requirements. The solid rocket motor consists of a motor case, propellant, insulation/liner, nozzle, and igniter arm/fire assembly.

Control Section. The primary functions of the control section assembly are to position the missile fins, provide the missile electrical power while in flight, and support selected pyrotechnic functions.

Warhead Assembly. The primary function of the warhead assembly is to carry, protect, and dispense the missile payload. The warhead assembly consists of a rolled aluminum shell with aluminum support structures and front and rear bulkheads. A center tube connects the bulkheads and provides a central wire route. In addition to the payload, the warhead assembly contains a skin severance system which controls the release of the payload at the required time.

The M39 Missile Warhead is used against personnel and soft targets normally with a TLE of 150 m or less. Larger TLEs may reduce effectiveness. Each missile dispenses a cargo of approximately 950 antipersonnel and antimateriel (APAM) M74 grenades over the target area. Warhead event is initiated by an electronic time fuze (M219A2) that is set in the same manner as the M445 electronic time fuze of the M26 rocket. The fuze detonates shaped charges mounted to the skin and bulkheads. This in turn severs the skin. By means of centrifugal force and airstream currents, the M74 grenades are distributed over the target area. Arming of the M74 grenades is accomplished by the spin action which is induced on the individual grenade. The M74 grenade is filled with composition B explosive filler and is covered by a steel shell. Upon impact and detonation each grenade

breaks up into a large number of high-velocity steel fragments that are effective against targets such as truck tires, missile rounds, thin-skinned vehicles, and radar antennas. This submunition is not effective against armored vehicles. The M74 grenade also contains incendiary material and has an antipersonnel radius of 15 m.



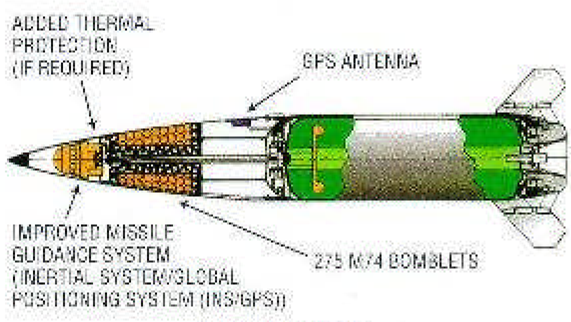
Army TACMS Block I:

SYSTEM DESCRIPTION:
The Army Tactical Missile System (Army TACMS) resulted from a need to engage high priority targets at ranges beyond those of existing weapons. The Army TACMS Block I replaces the conventional Lance system. Block I is a ground launched, deep fires missile system consisting of a surface-to-surface guided missile with an anti-personnel/anti-materiel (APAM) warhead consisting of approximately 950 M-74 bomblets.
The missiles are fired from the Multiple Launch Rocket System (MLRS) modified M270 launcher. The missiles are deployed within the ammunition loads of corps MLRS battalions and/or division artillery batteries. The Army TACMS includes guided missile and launching assembly, test set, guided missile system, training set, guided missile system: M165, trainer, test device guided missile: M70, modified M270 launcher, and Army TACMS missiles facilities.

SYSTEM CHARACTERISTICS:
The Army TACMS Block I is a semi-ballistic missile with an APAM warhead that contains approximately 930 M-74 bomblets. There is 1 missile per guided missile and launching assembly and 2 missiles per launcher load. The missile will engage targets throughout the corps area of influence and is designed to destroy tactical missile launchers, suppress air defense, counter Command, Control, and Communications (C3) complexes and disrupt logistics.

MISSION:
Provides deep fires in support of deep attack/precision strike operations.
Target Set: 2nd Echelon Maneuver Units; Air Defense Units; Command and Control Sites; Surface-to-Surface Missile Units; Forward Area Refueling
Resupply Points (FARRPS).
The Army TACMS Block I missile underwent IOT&E in 1990. The most significant deficiency noted in the DOT&E BLRIP report that followed the IOT&E was that the Army did not demonstrate the ability to conduct target acquisition at the Block I engagement ranges. However, DOT&E assessed the system to be operationally effective, and the system entered full-rate production. Army TACMS Block I was deployed and fired in Operation Desert Storm.

Army TACMS Block IA



BLOCK IA APAM

SYSTEM DESCRIPTION:

Army TACMS Block IA is an extended range variant of the Army TACMS Block I missile. The Block IA effort entails integrating an onboard Global Positioning System (GPS) with antenna and software into an inertial navigation system and reducing the Block I payload from 950 M-74 bomblets to approximately 300 M-74 bomblets to achieve the required accuracy and extended range. To compensate for the reduced payload, the accuracy of the missile has been improved with inflight GPS updates. If GPS is rendered inoperable, the Army TACMS Block IA reverts to inertial guidance only and maintains Block I accuracy. The missile is fired from the Improved Position Determining System of the M270 "deep strike" launcher and the M270A1 launcher with the improved fire control system (IFCS) and improved launcher mechanical system (ILMS).

SYSTEM CHARACTERISTICS:

Army TACMS Block IA is a semi-ballistic missile that provides near all weather, day and night, precision strike capability at ranges beyond existing cannons, rockets, and missiles. Block IA uses the guided missile control and propulsion systems of the Army TACMS Block I missile. The Block IA warhead will use a majority of the Block I warhead components except the payload of anti-personnel/anti-materiel (APAM) M-74 bomblets will be reduced in the Block IA to extend its range. Block IA uses an improved version of the Army TACMS Block I Missile Guidance Set (IMGS) to achieve the improved accuracy needed to meet the Block IA system requirements for mission accuracy. The IMGS uses an embedded GPS receiver (EGR) to receive and process GPS satellite navigation signals and integrate the GPS data into the inertial guidance scheme to improve navigational accuracy. There is 1 missile per guided missile and launching assembly and 2 missiles per launcher load.

DEVELOPMENT ACTIVITIES

Prior to completion of the MLRS Improved Fire Control System (IFCS), the M270 launcher requires modifications that include the installation of an interim improved positioning and determining system (IPDS) and an interface for connecting a KYK-13 cryptographic loading device. The IPDS, the positioning and navigation unit of the future IFCS, employs ring laser gyros, force-rebalanced accelerometers, and the GPS to provide launcher location and navigation data. The Army will field one battalion of IPDS-equipped launchers until IFCS is fielded in the M270A1 launcher program.

In April 1996, the PEO Tactical Missiles conducted a Low-Rate Initial Production (LRIP) review of the program and authorized procurement of 70 Block IA missiles. The Army conducted three missile launches prior to the LRIP review, and five additional missile firings in the formal developmental testing between February and October 1996. The IOT&E, consisting of a ground phase at Fort Sill, Oklahoma, and a two-missile live firing phase at White Sands Missile Range, New Mexico, was conducted in August and

September 1996. Live Fire testing, consisting of an arena test (22 M74 bomblet firings) and two end-to-end missile firings (one DT shot against a 9-target array and one OT shot against a 15-target array), was completed in September 1996.

During 2QFY97, DOT&E completed its assessment of the Army TACMS Block IA and participated in the Integrated Product Team preparations for a March 1997 Army Systems Acquisition Review Council Milestone III decision. Problems identified in the Army's and DOT&E's assessments caused the Army Acquisition Executive (AAE) to delay the Milestone III decision until 2QFY98, and grant approval for a second LRIP contract award for 97 missiles.

The Army Training and Doctrine Command (TRADOC) is coordinating a sensor-to-shooter assessment to determine the Army's capabilities to detect targets at the Block IA ranges and to process that information in a timely manner. They have established a General Officer Steering Committee to monitor progress of the assessment. The GOSC includes the Deputy Under Secretary of the Army for Operations Research; the Assistant Deputy Chief of Staff for Operations–Force Development; The Deputy for Systems Management; the Program Executive Officer (PEO) Tactical Missiles; PEO, Intelligence and Electronic Warfare; Commandant, U.S. Army Field Artillery School; Commandant, U.S. Army Intelligence Center; and Commanding General, U.S. Army Operational Test and Evaluation Command.

Program Manager (PM), Army TACMS, is sponsoring an excursion to a Joint Staff study of Joint Suppression of Enemy Air Defenses (JSEAD) in a Southwest Asia scenario. The excursion is intended to demonstrate the inflight survivability of the Block IA in an active threat air defense environment. If necessary, TRADOC will update the Cost and Operational Effectiveness Analysis based on the study's determination of missile survivability. PM, Army TACMS, sponsored additional live fire testing to improve characterization of M74 bomblet effects against the threat targets. Those tests include employment of a live warhead against trucks and fuel containers, and arena testing to characterize bomblet pyrophoric effects against targets configured with fuel and ammunition.

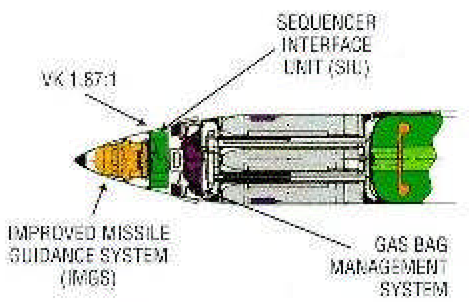
After analysis of the IOT&E, LFT&E and flight test data which were generated in accordance with the approved TEMP, DOT&E assessed the Army TACMS Block IA to be not operationally effective, and not operationally suitable as tested. The DOT&E assessment was based on deficiencies in the target acquisition system at Block IA ranges, missile performance, bomblet lethality, missile inflight survivability and reliability. The Army's conclusion was that ATACMS Block IA was suitable and marginally effective. The AAE's Acquisition Decision Memorandum (ADM) stated that a favorable decision at the Milestone III will be contingent on addressing the following issues.

- Using Joint Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) architecture, can the Army consistently demonstrate the ability to detect and locate targets with the required accuracy at the extended range of the Block IA system, and then provide the targeting data to the Deep Operations Coordination Cell in a timely manner?

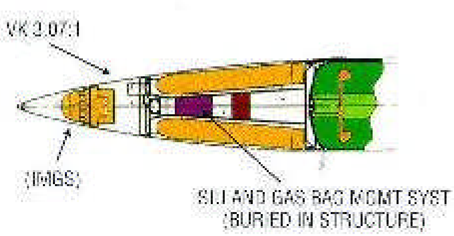
- Can the Army demonstrate the ability to achieve the required level of effects on all of the Block IA Operational Requirements Document (ORD) targets?
- Can the Army demonstrate, through modeling, inflight survivability when attacking the ORD targets in a realistic operational scenario?
- Can the overall missile reliability (inflight and prelaunch), and launcher reliability requirements of the Army TACMS Block IA system be achieved during the life of the system?

The cause of the low prelaunch reliability was identified to be a problem in the launcher Global Positioning System software which affected the transfer of a precision timing signal to the missile. The Army corrected the problem and tested the corrected software in January demonstrating that the software performed as intended. On 25 June and 03 December 1997 they further demonstrated the fix with successful test flights.

Army TACMS Block II



BLOCK II BASIC BAT (13)



BLOCK IIA - 6 P3I BAT

SYSTEM DESCRIPTION:
The Block II Army Tactical Missile System for the Army is a long range, all weather, day/night, tactical missile designed to defeat critical high pay-off targets in support of Corps level deep operations. The Block II variant is a pre-planned product improvement (P3I) to the Army TACMS Block I and IA missile systems specifically designed to kill moving armored targets and surface-to-surface missile (SSM) transporter erector launchers (SCUD TELs). The Block II carries 13 BAT or P3I BAT brilliant submunitions. The Block II carrying the basic BAT is designed to destroy critical moving armored formations such as a reserve tank battalion moving from assembly areas in the enemy's rear. The Block II equipped with P3I is designed to seek out and destroy both stationary targets, such as the SCUD and moving TELs and tanks as well. As with the Block IA missile, the Block II guidance set is augmented by an on-board GPS to improve accuracy.

SYSTEM CHARACTERISTICS:
Army TACMS Block II is a conventional semi-ballistic surface-to-surface designed to attack targets beyond the range of existing field artillery cannon and rocket fires. The missile is fired from the launcher assigned to MLRS Corps Artillery Unit. There is 1 missile per guided missile and launching assembly and 2 missiles per launcher load. The Block II utilizes the Block I missile control and propulsion set, the Block IA guidance and inertial navigation set, and unique hardware and software to assure necessary missile communication with the BAT and P3I BAT submunition. Thrust for

the missile is provided by a solid propellant rocket motor which is ignited by an igniter arm/fire device. Control of the missile during flight is accomplished by four fins located 90' apart in the control section of the missile.









ATACMS Block II/ Brilliant Anti-armor Technology (BAT)

The ATACMS Block II/ Brilliant Anti-armor Technology (BAT) submunition is a precision engagement weapon that takes advantage of the US ability to develop a missile that integrates stand-off delivery accuracy with a submunition that has the required effectiveness to kill moving armor columns in the deep battle zone. This precision engagement capability will enable the joint US and combined allied forces to interdict enemy formations through synchronized operations from dispersed locations. This ability to engage deep targets will contribute to the joint effort that assures dominant maneuver.

Army ACAT ID Program

Missile Quantity 1,528
Submunition Quantity- 19,871
Total program cost $4,007.1M
Average unit cost $1.46M
LRIPs - 1QFY98/1QFY99
Full-rate Production 4QFY00

Prime Contractor

Lockheed-Martin Vought Systems
(Missile)
Northrop-Grumman (submunition)

The Block II ATACMS missile is the delivery system chosen by the Army to replace the now defunct Tri-Service Stand-off Attack Missile as the deep attack carrier for the Brilliant Anti-Armor Technology Submunition (BAT). The BAT is a self-guided submunition that uses on-board sensors to seek, identify, employ a top attack engagement profile, and destroy moving tanks and other armored combat vehicles. It uses an acoustic sensor to seek out its armor targets, and infra-red sensor to engage the vehicles.

After dispense of the 13 submunitions from the ATACMS Block II missile, the weapons glide to their preprogrammed target area, and each selects a discrete target within its assigned acoustic segment of the formation. Once a target has been acquired by the terminal infra-red seeker, the weapon guides to terminal impact and uses a tandem shaped-charge warhead to destroy the vehicle. With a relatively large acoustic search/glide footprint, the BAT is capable of accommodating target location ambiguity inherent with the engagement of moving formations.

Army TACMS Block IIA

The Fiscal Year 2001 Army budget request included decisions to restructure or "divest" a number of programs in order to provide some of the resources to support its

transformation to achieve the ambitious deployment goals outlined in the October 1999 Army Vision. The restructured programs are the Crusader and the Future Scout and Cavalry System. The "divestitures" include Heliborne Prophet (Air), MLRS Smart Tactical Rocket (MSTAR), Stinger Block II, Command and Control Vehicle (C2V), Grizzly, Wolverine, and the Army Tactical Missile System Block IIA. Funding for these programs was reallocated to fund the Army Vision transformation strategy. **SYSTEM DESCRIPTION:**

Army TACMS Block IIA is an extended range variant of the Block II system. The Block IIA is a semi-ballistic missile used to deploy six P3I BAT Brilliant Anti-Armor submunitions at ranges beyond the Block II system. Block IIA is a near all-weather, day and night, precision strike system as ranges beyond the capability of existing cannons, rockets, and missiles. The P3I BAT is a pre-planned product improvement to the BAT submunition to provide enhanced acquisition capability and an improved warhead for use against an expanded target set to include moving or stationary hot or cold targets. The Block IIA program specifically consists of modifying the payload section of the Block IA missile to carry and dispense a payload of six P3I BAT submunitions at Block IA ranges.

SYSTEM CHARACTERISTICS:

The Block IIA is a modified version of the Block II missile and will use common components of the Block I, IA and II systems. The Block IIA will use the Block IA Improved Missile Guidance System with Global Positioning System (GPS). The Block IIA integrates the P3I BAT submunition into the Army TACMS Block IA missile. Block IIA will use the Block II Sequencer Interface Unit and modifications to the Missile Test Device needed to accommodate the P3I BAT.

The Block II missile modification program entered EMD in May 1995. A BAT limited rate initial production (LRIP) decision is scheduled for 1QFY98, missile LRIP in 1QFY99. The system will accomplish the operational test and evaluation in two phases through FY99 and FY00. The milestone III production decision is currently planned for late 1QFY00.

Brilliant Anti-Armor Submunition (BAT)

SYSTEM DESCRIPTION:

The BAT is an acoustic and infrared (IR) guided submunition that autonomously searches for, tracks and defeats armored and critical mobile targets. The BAT is a propulsionless, aerodynamically controlled vehicle (glider). The BAT is delivered to the target vicinity by the Army Tactical Missile System (Army TACMS), which is launched from the M270 Multiple Launch Rocket System (MLRS). As such, BAT is part of the MLRS Family of Munitions (MFOM). The submunition is designed to provide capability to attack deep, high-payoff and time critical targets.

The dual mode (acoustic/IR) seeker and gliding capability accommodate large target location uncertainties due to such efforts as target motion, configuration or orientation; winds, delivery vehicle accuracy or delivery patterns. This flexibility also accommodates variability in the decision-to-shooter timeline and obviates the need for inflight targeting updates to the Army TACMS. **SYSTEM CHARACTERISTICS:**
Prior to dispense, the BAT thermal battery is initiated, the flight software and mission parameters are downloaded, and the IMU is aligned. After dispense at subsonic and supersonic speeds, the BAT stabilizes itself, slows to acquisition speeds, and deploys its aerodynamic surfaces. The BAT acquires the target or target groups, glides to the immediate target area and selects an individual vehicle to be engaged, ensuring that not all BATs pick the same target. A top down, hit-to-kill terminal profile is prosecuted toward a selected vulnerable region of the targeted vehicle. On impact, the tandem conventional shaped-charge warhead is detonated, assuring an M, F, or K-kill and collectively (with the other dispensed BATs) securing delay, disruption or destruction of the targeted enemy unit.
MISSION:
Deep attack interdiction, kill moving armored combat vehicles. In addition, P3I BAT's mission includes: cold stationary targets and surface-to-surface missile transporter erector launchers and heavy multiple rocket launchers.

Pre-planned Product Improvement (P3I) BAT:

SYSTEM DESCRIPTION:
P3I BAT is a pre-planned product improvement to the BAT submunition. P3I BAT retains the basic physical characteristics of BAT while offering enhanced acquisition capability and an improved warhead. P3I BAT is designed to provide deep attack interdiction against an expanded target set to include armored combat vehicles (moving or stationary), stationary targets (hot or cold), surface-to-surface missile transporter erector launchers and multiple rocket launchers. P3I BAT will be delivered to the target area by both the Army TACMs Block II and Block IIA missiles. P3I BAT is an MSTAR candidate as the smart munition delivered by MLRS rockets. P3I BAT is designed to provide the Commander with a Deep Strike weapon capable of destroying, delaying and disrupting follow-on forces. P3I BAT offers the Commander greater flexibility during combat planning and operations.
SYSTEM CHARACTERISTICS:
P3I BAT uses dual-mode sensors capable of acquiring and destroying moving or stationary and hot or cold targets. The submunition uses an improved, selective shaped charge warhead. The warhead more (hard vs soft target detonation) is determined prior to submunition impact. The sensors are more robust in adverse weather against countermeasures offering enhancements over the baseline BAT submunition.

Development and Testing Activity

The principal test activities to date have been developmental events, including Design Verification Tests (DVTs) and Contractor Development Tests (CDTs). The DVTs were single submunition drops from a commercial fixed wing aircraft. The sequence of the

DVT testing built up to increasingly representative submunition evaluations. The DVT sequence both tested the hardware configuration and contributed to the modeling and simulation data base that will be eventually accredited for use in the operational test and evaluation phase. The CDT series builds upon the DVT results and culminates in full system Engineering Design Tests of missile/submunition function. Because of the importance of all the developmental activity in the validation of the modeling and simulation to the overall program evaluation, DOT&E and Army operational test agency representatives observed key test events throughout both DVT and CDT.

The evaluation of the Army TACMS Block II program also relies on a series of supporting test events and exercises to demonstrate and evaluate the end-to-end system performance. All phases of the Army's decide, detect, deliver concept of employment will be evaluated. Key evaluation events include the MLRS Family of Munitions (MFOM) Force Development Test and Evaluation (conducted in FY95), ongoing Joint STARS System testing, and data gathering activity at selected joint exercise and training events.

The ATACMS Block II Test and Evaluation Master Plan outlines an operational evaluation strategy and supporting resources. The TEMP was approved by DOT&E in July 1995 and the testing is being conducted in accordance with the approved strategy.

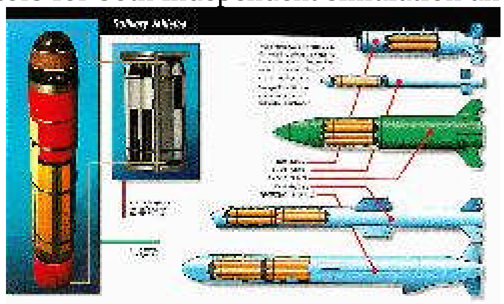
DOT&E assessment of the developmental flight testing to date is cautionary. The most production representative tests have been the CDT series. Of the fourteen CDT flight events, six were successful, three were failures, one was a no-test, and the remainder have not yet been through a scoring conference. The current point estimate of operating reliability of the submunition is .67 (LRIP exit criterion is .68, final ORD requirement is .86).

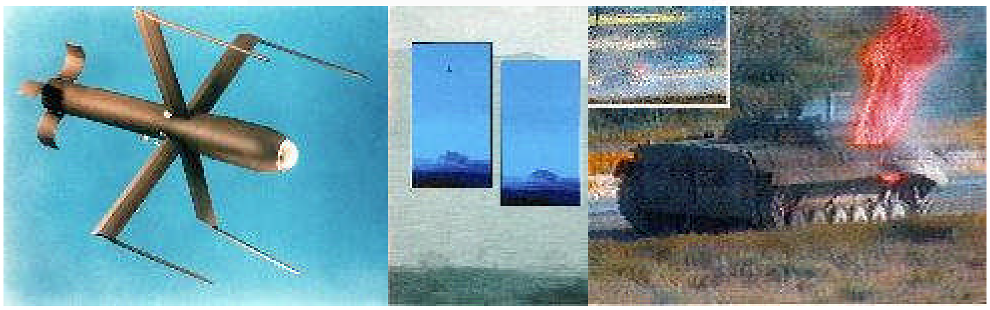
The failures/no test conditions and attendant remedial actions have been:

- CDT-1 (no test)-- IR dome fogging and deployment system malfunction. Engineering development of a dome heater. Resequence tail and fin deployment.
- CDT-4--Deployment system malfunction. Redesign the deployment system restraining band system.
- CDT-6 (dual drop)--Two failures induced by contaminated cooling gas and seeker cooling design. Redesign of the gas flow venturi and enhanced quality control requirements on gas supply bottles.
- CDT-8.1-- Premature detonation of warhead. Fault tree analysis underway.
- CDT-9 --Submunition failed to acquire a target.
- CDT-10 --Submunition failed to acquire a target.
- CDT-10B --Parachute squib wires crossed.
- CDT-11 --Submunition failed to acquire a target.

The Live Fire Test and Evaluation (LFT&E) strategy was developed to take advantage of expected hits on target vehicles in the drop tests of submunitions with live warheads. In the past eighteen months, there have been only three live warhead drops, and only one of these hit a target. Each test event, regardless of success or failure, has contributed to the overall modeling and simulation validation and accreditation schema. The program office has been aggressive in implementing a strategy of early involvement of operational

testers in order to insure that the developmental test data is available to the DOT&E and Army operational evaluators for both independent simulation and early assessments.



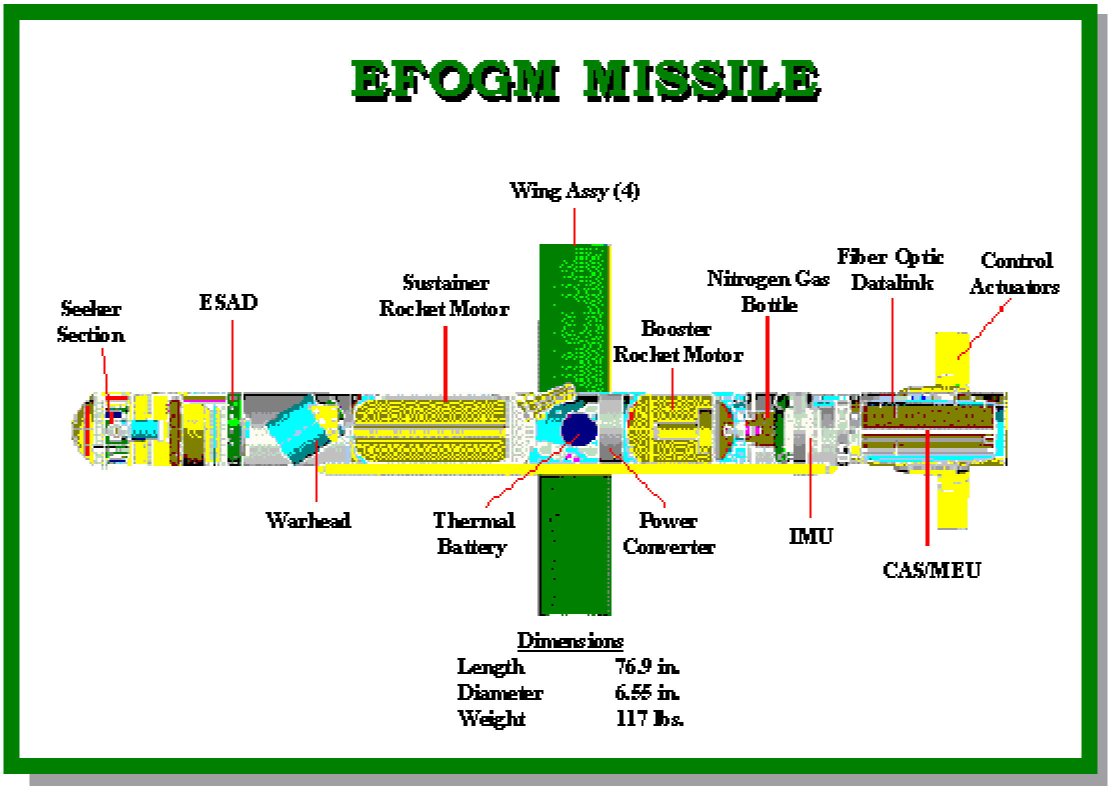


Enhanced Fiber Optic Guided Missile (EFOGM)
Guided Missile, Surface Attack: YMGM-157B

The YMGM-157B is a terminal homing missile that utilizes a fiber optic data link to transmit and receive command and sensor data with a mobile fire unit to find and defeat threat targets masked behind hills, foliage or in urban settings. The missile employs a high resolution infrared video camera in the nose of the missile to provide the gunner with a unobstructed view of the surrounding terrain from the missile's perspective. The gunner can pan the missile's seeker to investigate targets of opportunity as the missile flies a non-ballistic flight path around or over obstructing terrain to pre-selected target areas. Once launched, the missile utilizes inertial instruments to automatically navigate the missile along a preprogrammed flight path up to 15 kilometers in length. The gunner is utilized as a discriminating man-in-the-loop sensor to identify and designate targets and to assist in refining the missile's aimpoint on vulnerable locations of the target. A top attack trajectory, exceptional terminal precision and a shaped charge kill mechanism work together as an extremely lethal combination against heavily armed targets masked behind cover. No other Army missile provides this kind of man-in-the- loop capability to minimize fratricide while inflicting precise kills in an integrated battlefield.

System Characteristics:

- 8 Ready to Fire, On-Board Missiles
  - 2 Missiles in Flight Simultaneously
  - Maintains Real-Time Control/Man in the Loop
  - Automatic Navigation to Target Area
- Lethal Against:
  - Armored Vehicles
  - Helicopters
  - Other High Value Targets
- In-Flight Reconnaissance
- Minimizes Collateral Damage/Fratricide
- Pinpoint Destruction of Hard Targets
- Capable of Flying in Day, Night or Adverse Weather Conditions
- High Survivability
  - Non-ballistic Trajectory
  - Launch Position Set Back
- System Mounted on a Heavy HMMWV Chassis
- Command, Control, Communications, and Intelligence Capabilities
- Embedded Training Eliminates Need for Special Training Devices and Reduces Cost


EFOGM MISSILE
Wing Assy (4)
Seeker Section
ESAD
Sustainer Rocket Motor
Booster Rocket Motor
Nitrogen Gas Bottle
Fiber Optic Datalink
Control Actuators
Warhead
Thermal Battery
Power Converter
IMU
CAS/MEU
Dimensions
Length 76.9 in.
Diameter 6.55 in.
Weight 117 lbs.

M26 Multiple Launch Rocket System (MLRS)

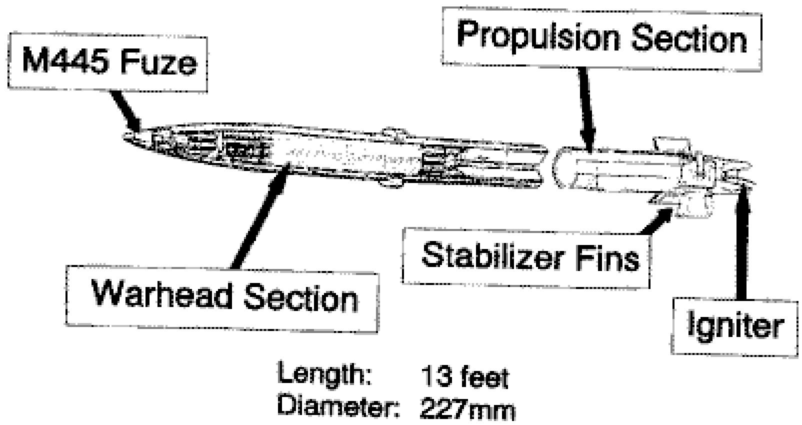
The Multiple Launch Rocket System (MLRS) provides the Army an all-weather, indirect, area fire weapon system to strike counterfire, air defense, armored formations, and other high-payoff targets at all depths of the tactical battlefield. Primary missions of MLRS include the suppression, neutralization and destruction of threat fire support and forward area air defense targets. The Multiple Launch Rocket System is a versatile weapon system that supplements traditional cannon artillery fires by delivering large volumes of firepower in a short time against critical, time-sensitive targets. These targets often include enemy artillery, air defense systems, mechanized units, and personnel. MLRS units can use their system's "shoot and scoot" capability to survive while providing fire support for attacking manuever elements. MLRS is not intended to replace cannon artillery, but has been designed to complement it.

MLRS performed extremely well in Operation Desert Storm (ODS) in which significant numbers of launchers were deployed. All operational requirement were met and, in most cases, exceeded levels for readiness, reliability and maintainability.

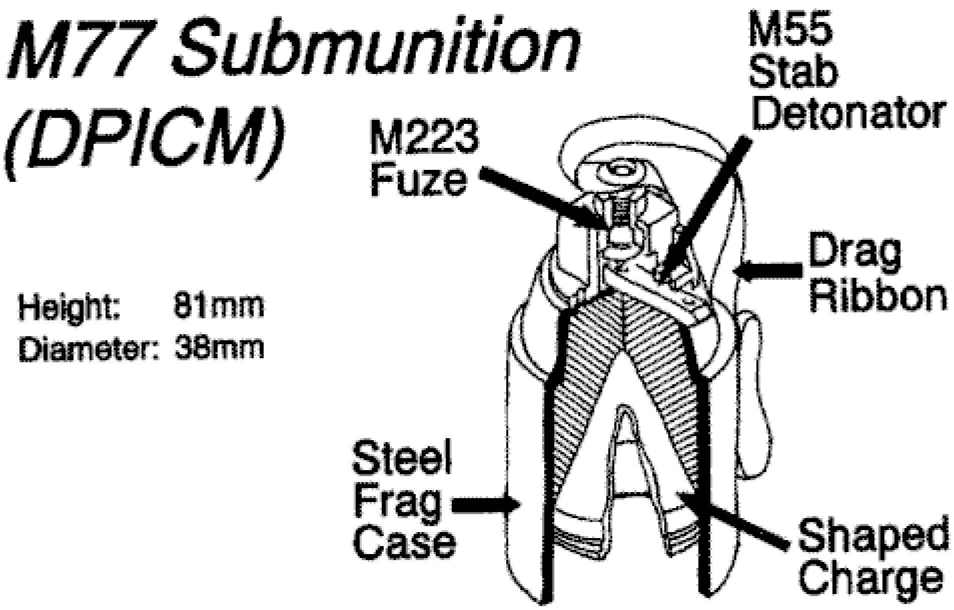
The MLRS rockets are tube-launched, spin-stabilized, free-flight projectiles. The rockets are assembled, checked, and packaged in a dual-purpose launch-storage tube at the factory. This design provides for tactical loading and firing of the rocket without troop assembly or detailed inspection. Major components of the rocket assembly include four stabilizer fins, a propulsion section, and a warhead section. Propulsion for the rocket is provided by a solid propellant rocket motor. An umbilical cable, passing through the aft end of the launch tube, links the FCS to an igniter in the rocket nozzle. The motor is ignited by an electrical command from the FCS. Each rocket is packaged with the four fins folded and secured by wire rope retaining straps. As the rocket moves forward upon firing, lanyard devices trigger a delayed strap-cutting charge. After the rocket leaves the launch tube, the charge cuts the straps. This allows the fins to unfold and lock. The M28 and M28A1 rockets' LPCs have an additional fin release device to ensure deployment.

The MLRS rocket follows a ballistic, free-flight (unguided) trajectory to the target. The propulsion provided by the solid propellant rocket motor is the same for each rocket, so rocket range is a function of LLM elevation. The four stabilizer fins at the aft end of the rocket provide in-flight stability by maintaining a constant counterclockwise spin. The initial spin is imparted to the rocket through spin rails mounted on the inner wall of the launch tube.

M26 Rocket

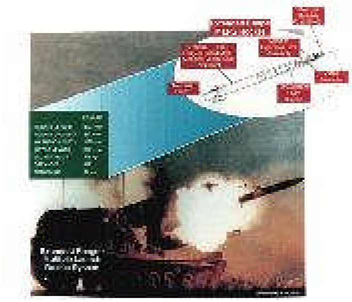


M77 Submunition (DPICM)



The M77 submunitions detonate on impact. The antimateriel capability is provided through a shaped charge with a built-in standoff. The M77 can penetrate up to four inches of armor. Its steel case fragments and produces antipersonnel effects with a radius of 4 m.

MLRS M26 basic tactical rocket



SYSTEM DESCRIPTION:
The MLRS M26 basic tactical rocket was designed to complement cannon weapons in the tactical fires arena. The M26 tactical rocket provides devastating effects in attacking critical, time sensitive targets with large volumes of firepower in a very short time. The M26 is a free flight unguided tactical rocket that provides an all weather, indirect fire capability to attack artillery and air defense systems, personnel, and light materiel targets. The M26 tactical rocket warhead contains 644 M77 dual purpose improved conventional munition submunitions which can be deployed to cover a 0.23 square km area.
SYSTEM CHARACTERISTICS:
Six M26 rockets are loaded in the launch pod/container (LP/C) at the factory. The six M26 rockets are shipped, stored, and fired from the LP/C. The M26 rocket is a wooden round with a shelf life of at least 15 years. The M26 provides the firepower superiority needed to silence enemy artillery and critical targets. This awesome capability was termed "steel rain" by the Iraqi commanders during Desert Storm.

Extended Range Rocket (ER) MLRS

SYSTEM DESCRIPTION:
The extended range MLRS is an ACAT II program within the MLRS Project Office. The ER MLRS is a free flight, area fire artillery rocket designed to engage targets beyond the range of the existing MLRS. The development program includes the addition of a low level wind measuring device on the M270 launcher to sustain accuracy and effectiveness at the longer ranges and the incorporation of a self destruct fuze on each submunition to increase safety for friendly maneuver forces.
SYSTEM CHARACTERISTICS:
The ER MLRS is similar to the basic MLRS with the following changes. The ER MLRS includes a lengthened rocket motor and smaller warhead section with fewer submunitions, a new no-load detent system for securing and releasing the rocket, a modified center core burster, and a new warhead fuze. Additionally, each M85 Dual-Purpose Improved Conventional Munition (DPICM) submunition will be equipped with a self-destruct fuze. The system also includes the addition of a low level wind measuring device on the launcher.

The first in a series of low rate initial production (LRIP) contracts was awarded to Lockheed Martin Vought Systems (LMVS) on 31 July 1996 for 1326 ER-MLRS rockets. In February 1997, a second LRIP contract was awarded for an additional 1500 rockets. Delivery of these rockets was scheduled to start in 2QFY98. However, this start date was put into jeopardy due to the continuous development of the XM85 Dual Purpose Improved Conventional Munition (DPICM) grenade. The XM85 will reduce the

hazardous dud rate (HDR) of the current M77 grenade to less than one percent, greatly improving friendly force maneuver.

Production and fielding of ER-MLRS rockets continues, with M26A2 ER-MLRS rockets fielded to storage sites in Korea for US Forces Korea. This is in accordance with the direction of the Deputy Chief of Staff for Operations and Plans (DCSOPS). In October 1997, DCSOPS, in response to an urgency of need request from Commander, US Forces Korea, waived the less than one percent hazardous dud rate (HDR) and directed that all ER-MLRS rockets (approximately, 4,300) be fielded to USFK by the end of 4QFY99. Currently, ER-MLRS rockets are loaded with the M77 Dual Purpose Improved Conventional Munition (DPICM) and are designated the M26A2. The M77 is the same DPICM as that in the M26 basic MLRS rocket. It has a hazardous dud rate of approximately 4%.

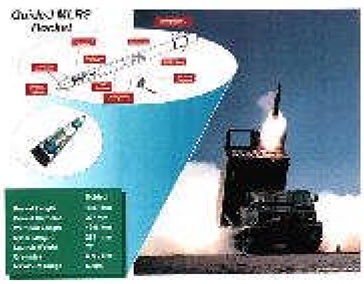
A production contract was awarded to the designer/builder of the M235 Self Destruct Fuze (SDF), an integral part of the M85 DPICM grenade. The M85 will reduce the hazardous dud rate (HDR) of the current M77 grenade to less than one percent, greatly improving friendly force maneuver. Upon completion of the equipment necessary to produce the SDF at the required high rates, approximately 1,200 M26A1 versions of the ER-MLRS will be manufactured and delivered to USFK in FY00. This will conclude the production run of ER-MLRS at approximately 4300 rockets for the US Army. Additionally, contracts were awarded to LMVS to produce M26A2 rockets for the Republic of Korea (ROK) and Bahrain. Delivery of rockets to ROK and Bahrain was in 2QFY99 and 3QFY99. Additional sales to foreign customers of both versions of the ER-MLRS were concluded prior to the end of 2QFY99.

M28A1 Reduced Range Practice Rocket (RRPR)

SYSTEM DESCRIPTION:
The M28A1 Reduced Range Practice Rocket is a short range practice rocket used to train operational MLRS units. The design maximizes the number of firing ranges that will support MLRS live fire training. The rocket motor is the same one used by the M26 Tactical MLRS Rocket.

SYSTEM CHARACTERISTICS:
The M28A1 is a short range training rocket used to train troops. The design is a standard M26 rocket motor with a ballasted blunt nosed warhead designed for training/test sites with short ranges. A special application software module is required for the launcher to recognize and launch the RRPR.

M30 Guided Multiple Launch Rocket System (MLRS)



The United States entered into a cooperative Engineering and Manufacturing Development (EMD) program with the United Kingdom, Germany, France and Italy to develop a new guided rocket for the Multiple Launch Rocket System. The rocket, known as the M30 GMLRS, will have increased range, accuracy and lethality. The GMLRS EMD represents another example of international cooperation to produce a common product to achieve interoperability, while sharing and minimizing costs and risks.

Prime contract for the EMD phase was awarded on 4 November 1998 to Lockheed Martin Vought Systems (LMVS) by the US on behalf of the GMLRS partner nations. The EMD contract is a Cost Plus Award Fee (CPAF) type contract worth approximately $121 million and was scheduled to be completed in 48 months. LMVS was selected based on its previous experience and involvement with MLRS launchers and rockets.

The GMLRS EMD contract is one of the first Army programs to use the "Alpha Acquisition" contracting process in which the Integrated Product Team (IPT) approach is used to arrive at an acceptable contract between the prime and the Government in a timely manner. This approach includes the reduction of procurement timelines through the elimination of unnecessary stages, by the adoption of partnering agreements between the contractor and the Government, and by the establishment of collaborative IPTs.

Final plans for GMLRS production in the US and Europe are still being formulated. US production is scheduled to begin in FY02 with a planned buy of approximately 100,000 rockets.

The U.S. Army Aviation and Missile Command (AMCOM) Research, Development and Engineering Center (RDEC), with support from industry, conducted an Advanced Technology Demonstration (ATD) to design, fabricate, and flight test a low cost guidance and control (G&C) package for the Extended Range MLRS rocket.

The Guided Multiple Launch Rocket System (MLRS) Advanced Technology Demonstration [ATD 95-98] demonstrated a significant improvement in the range and accuracy of the MLRS free-flight artillery rocket. Improved accuracy results in a significant reduction in the number of rockets required to defeat the target (as much as sixfold at extended ranges). Other benefits include an associated reduction in the logistics burden (transportation of rockets), reduced chances of collateral damage and fratricide, reduced mission times (resulting in increased system survivability), and increased effective range for the MLRS rocket.

The ATD designed, fabricated, and flight-tested a low cost guidance and control package to be housed in the nose of the rocket, thus minimizing the changes to the current rocket. The Phase I G&C package, consisting of alow cost inertial measurement unit (IMU), a flight computer, and canards driven by electro-mechanical actuators, will be housed in the nose section of the rocket and will result in a significant increase in rocket delivery accuracy. The IMU package will provide a 23 mil accuracy sufficient for some MLRS warheads with the GPS-aided package providing a 10 meter CEP accuracy for warheads which require precision accuracy. The package to be demonstrated will result in a rocket which is more cost effective and more lethal while requiring no change to crew training procedures or maintenance procedures (during the 15-year shelflife). The guidance and control package will be designed with applicability to bomblet, mine, precision guided submunition, and unitary/earth penetrator warheads.
A second phase of the demonstration will add a Global Positioning System (GPS) receiver and antenna to demonstrate near precision delivery (5 meters CEP).

In 1994, the Missile Research, Development, and Engineering Center (MRDEC) initiated the Guided MLRS Advanced Technology Demonstration (ATD) with the support of the MLRS Project Office and the TRADOC System Manager for Rockets and Missiles. From the start, the ATD's exit criteria included not only accuracy improvements, but also a production cost goal of $12k for the guidance and control package, a zero maintenance requirement for the rocket, and a shelf-life of at least 15 years.

The design, fabrication, and testing of the guidance and control package took place within the MRDEC. The thermal battery, IMU, and GPS receiver were purchased off-the-shelf and tested by the MRDEC. The control actuation system, guidance computer, and all missile software were designed in-house by the MRDEC. The GPS antennas were designed and fabricated by the Army Research Laboratory. The canards, spring-opening tailfin assembly, telemetry package, roll bearing, missile skin sections, and wiring harnesses were designed and fabricated by LMVS. The MRDEC assembled the rocket and performed all system testing.

On May 13, 1998, a fully successful first flight of the Guided MLRS was conducted at White Sands Missile Range, New Mexico. This flight was launched from an M270 launcher, flown to a range of 49 km, demonstrated the proper operation of all missile subsystems, and achieved the 3-mil accuracy (150 meters at 49 km) goal when navigating in pure inertial mode using a Honeywell HG1700 IMU. Given the level of success on the first flight, the second flight was changed from an inertial flight to a GPS-aided flight. However, due to a bug in the vendor's GPS receiver software, only three satellites were tracked and the missile again flew a successful inertial flight using a Honeywell IMU. The third flight was conducted with the Litton LN-200 IMU. All subsystems performed well except for the IMU, which did not meet the accuracy goal. The fourth flight experienced a catastrophic tailfin failure at launch as well as an electrical short in the umbilical. After a root cause failure analysis and further tailfin testing, an adjustment was made to the tailfin assembly and a blocking diode was added to prevent umbilical shorts from damaging the rocket's electronics. The ATD culminated on February 11, 1999 with

a GPS-aided flight test in which the missile again flew 49 km and impacted only 2.1 meters from the target center, a resounding success.

The ATD successfully demonstrated all of its goals and has transitioned to the MLRS Project Office for a 4-year engineering, manufacturing, and development (EMD) phase. The EMD will be conducted as an international program with the United Kingdom, Italy, Germany and France. Current plans call for subsequent U.S. production of 90k rounds with the DPICM warhead. The accuracy demonstrated in flight number five's GPS-aided mode opens the door for future consideration of various MLRS unitary warheads and the addition of point targets to the MLRS target set.

MLRS Smart Tactical Rocket (MSTAR)

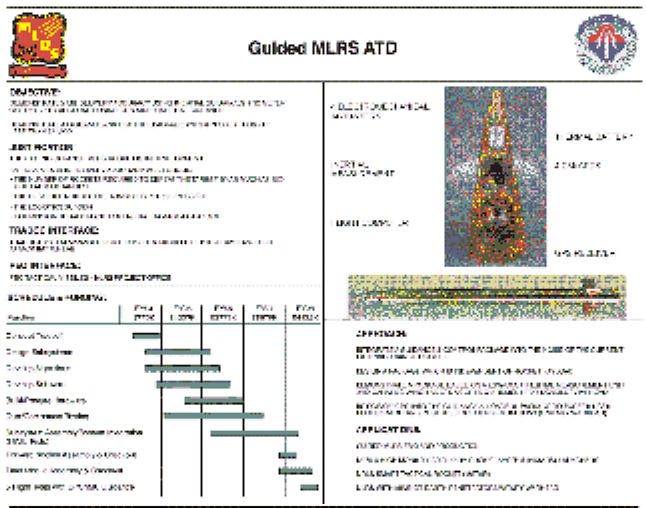
The Fiscal Year 2001 Army budget request included decisions to restructure or "divest" a number of programs in order to provide some of the resources to support its transformation to achieve the ambitious deployment goals outlined in the October 1999 Army Vision. The restructured programs are the Crusader and the Future Scout and Cavalry System. The "divestitures" include Heliborne Prophet (Air), MLRS Smart Tactical Rocket (MSTAR), Stinger Block II, Command and Control Vehicle (C2V), Grizzly, Wolverine, and the Army Tactical Missile System Block IIA. Funding for these programs was reallocated to fund the Army Vision transformation strategy.

SYSTEM DESCRIPTION:
The MLRS Smart Tactical Rocket is the next step in the evolution of the MLRS Rocket. The MSTAR will be a Guided (MSTAR) rocket carrying terminally guided, smart submunitions to a maximum range of approximately 60 km. After dispense, these munitions will use onboard sensors to detect and engage stationary or moving targets. An Advanced Technology Demonstration (ATD) is scheduled to begin in FY98, followed by EMD beginning in FY02.

SYSTEM CHARACTERISTICS:
Four candidate submunitions, P3I BAT, SADARM, LOCAAS, and Damocles are being evaluated to determine which one best meets Army requirements. Each candidate carries a sensor suite to detect, classify and engage high value targets. They use either explosively formed penetrators or shaped charges to penetrate armor.

GMLRS ATD Exit Criteria

	Current Baseline	ATD Threshold	ATD Goal
Cost of G&C Modifications	$0	$30,000	$14,000
Delivery Accuracy w/o GPS	Confidential	4-mil	2-mil
Delivery Accuracy w GPS	Confidential	30m CEP	10m CEP
Shelf Life (years)	15	15	15
Maintenance Requirement	none	none	none
Reliability	0.97	0.70	0.91



Guided MLRS ATD Exit Criteria

Demonstrate a low cost guidance and control package for the MLRS rocket. At extended ranges, large quantities of baseline rockets are required to defeat the target. With the addition of a guidance system, an improved delivery accuracy will be achieved. The number of rockets required to defeat the target will be reduced to one-sixth the current quantity at maximum ranges. The program will conduct test flights in FY98. Technologies that will be integrated include low cost inertial measurement units, GPS receivers and antennas, and a canard control package, all of which must be housed in the forward section of the MLRS rocket.

Supports: MLRS Family of Munitions, Rapid Force Projection Initiative (RFPI) ACTD, MLRS Smart Tactical Rocket, Precision MLRS (unitary warhead concept), High Mobility Artillery Rocket System (HIMARS)

FUNDING

PE	PROJ	FY95	FY96	FY97	FY98	FY99	FY00	FY01
63313	D380	1363	3779	3679	4332	0	0	0

STO Manager:	TSO:	TRADOC POC:
Allen E. Gamble	Irena Szkrybalo	Pat McCartney
MICOM RDEC	703-697-8434	Depth & Sim Attack Battle Lab
205-876-2511	DSN: 227-8434	405-442-5023
DSN: 745-2511		DSN: 639-5025

M55 rocket

The M55 Rocket was produced in the late 1950s to provide toxic chemical offensive capability for large target areas at long range. The rocket was designed for battlefield use, and consisted of an aluminum nozzle assembly with spring loaded fins, a rocket motor, and a fused warhead containing chemical agent. Designed to carry approximately 10 pounds of agent, the rockets are 83 inches tall, and are packed in a cylindrical fiberglass shipping and firing tube. The M55 rockets can also be recognized by three green bands around the body.

The M55 rocket consists of a chemical agent filled warhead attached to a rocket motor. It has a diameter of 115 millimeters (4.44 inches), is 78 inches long and weighs 57 pounds. The warhead is filled with either 10.7 pounds of GB or 10.0 pounds of VX. The rocket is stored in a shipping and firing tube. The tube is made of fiberglass reinforced resin, either expoxy or polyester. The warhead consists of a body, a burster well containing two bursters in series, a fuse adapater, and a point detonating fuse. The rocket motor consists of a body, nozzle-fin assembly, propellant, igniter assembly, and end cap. The propellant is an M28 double base [nitroglycerin and nitrocellulose] cast grain weighing 19.3 pounds. The rockets are stored with 15 rounds per pallet assembly secured with metal banding.

During the early 1960s, the U.S. Army stored M55 rockets at Black Hills Army Depot, South Dakota. Simulant rockets containing water or ethyl glycol instead of chemical agent were used to train soldiers on the proper handling and firing of the M55. Some of the explosive simulant rockets were used in storage igloo explosion tests, and the remains of some of those rockets were not recovered.

Other sites where the M55 rockets were formerly stored are Rocky Mountain Arsenal, Colorado and Okinawa, Japan. From Japan, they were later moved to Johnston Atoll in the Pacific. The rockets were briefly tested at Aberdeen Proving Ground, Maryland, and they were originally produced at Newport Army Ammunition Plant, Indiana. However, neither of these locations stored them for extended periods of time.

The U.S. chemical stockpile sites that still store the M55 rockets are Anniston Army Depot, Alabama, Blue Grass Army Depot, Kentucky, and Umatilla Army Depot, Oregon. M55 rockets are currently stored at Tooele Army Depot, Utah and are scheduled to be disposed in the near future.

Congress has mandated a deadline of December 31, 2004, for disposal of the U.S. chemical weapons stockpile. On January 23, 1995, the Army released a report to the public on the remaining storage life of the M55 rockets in the U.S. chemical weapons stockpile. As part of the Chemical Stockpile Disposal Program, the Army has performed several hazard analyses and risk assessments of continued storage of chemical munitions, including this recent study on M55 rocket propellant stability. These studies were conducted to determine if degradation of munitions and their contents could contribute to

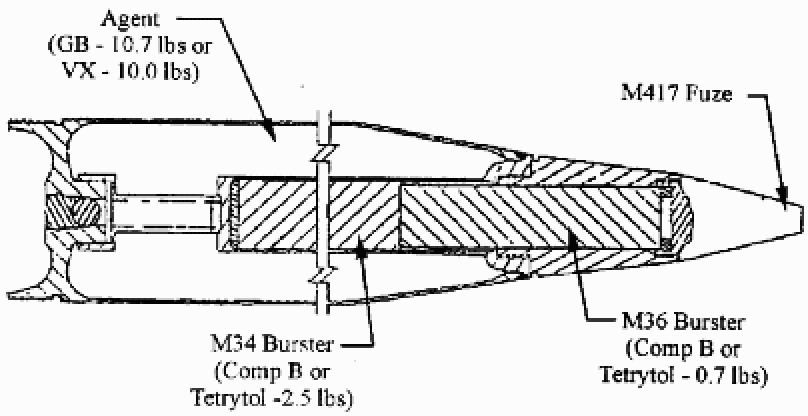
an increased risk to the public. The results indicate that the rockets can be safely stored until they are required to be disposed of by the congressionally-mandated deadline.

The M55 Rocket Storage Life Evaluation report focused on the rate of deterioration of the propellant found in the approximately 478,000 M55 rockets in the U.S. stockpile. These rockets - containing chemical agent fill, explosives, and propellant - are stored in five locations throughout the United States and at Johnston Island in the Pacific. Those five other locations are: Tooele, Utah; Anniston, Alabama; Umatilla, Oregon; Pine Bluff, Arkansas; and Blue Grass, Kentucky. As of March 1997, all rockets at Johnston Island have been safely destroyed.

Previous reports predicted the possibility of autoignition, caused by the natural depletion of the propellant stabilizer ranging from 27 to 100 years from the date of manufacture. The stabilizer is a substance that was added to the propellant to slow its degradation. Technical experts, including the manufacturer of the propellant, used two different methods to estimate the storage life of non-leaking M55 rockets. The most conservative model, one proposed by the propellant manufacturer, estimated that there is less than a one-in-a-million chance that a rocket will ignite by itself before the year 2013.

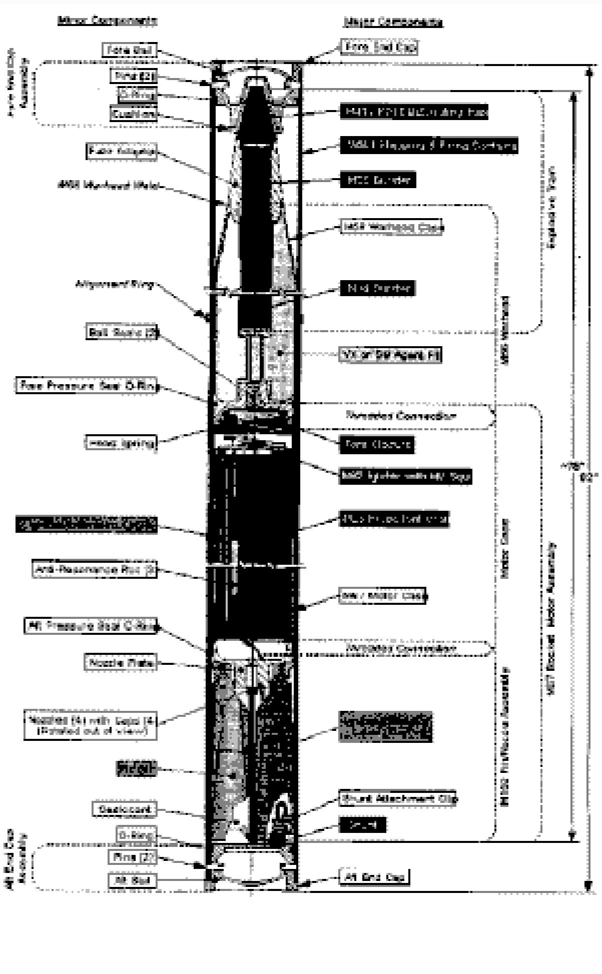
The report cautioned that its conclusions are limited only to non-leaking rockets. There is some evidence that internally leaking rockets in which the propellant came in direct contact with chemical agent could have shorter storage lives. The report noted that additional data should be obtained to gain more confidence in the estimate because the samples which were studied may not represent the condition of rockets at all storage locations. An investigation is under way to find whether propellant exposure to chemical agent increases the rate of deterioration of the stabilizer itself. The Army is currently addressing these issues as part of its Enhanced Stockpile Surveillance Program and will release a new report upon completion of this assessment.

1340-H520 ROCKET 115mm M55 GB
1340-H521 ROCKET 115mm M55 VX

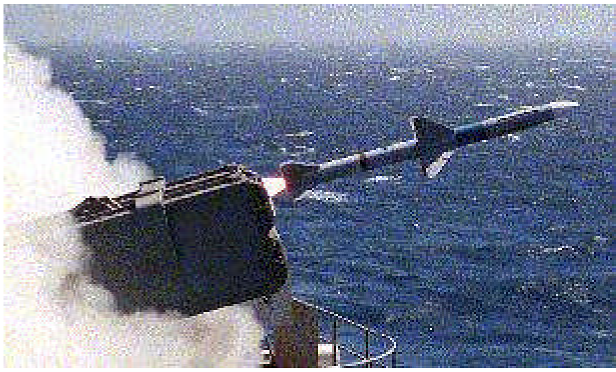


M56 Warhead Assembly

1340-00-716-1450 GB Rocket
1340-00-724-3567 VX Rocket



RIM-7 Sea Sparrow Missile



The Navy's RIM-7M *Sea Sparrow* and the Air Force's AIM-7 *Sparrow* are radar-guided, air-to-air missiles with high explosive warheads. They have a cylindrical body with four wings at mid-body and four tail fins. The Navy uses the *Sea Sparrow* version aboard ships as a surface-to-air anti-missile defense. The versatile *Sparrow* has all-weather, all-altitude operational capability and can attack high-performance aircraft and missiles from any direction. It is widely deployed by U.S. and NATO forces. The *Sea Sparrow* is found aboard many U.S. and NATO surface warships.

The NATO SEASPARROW Surface Missile System (NSSMS) Mk 57 is a medium-range, rapid-reaction, missile weapon system that provides the capability of destroying hostile aircraft, anti-ship missiles, and airborne and surface missile platforms with surface-to-air missiles. The NSSMS can also be used to detect missile launchings by a surface vessel utilizing the NSSMS surveillance radar capability. The NSSMS consists of a Guided Missile Fire Control System (GMFCS) Mk 91 and a Guided Missile Launching System (GMLS) Mk 29. The GMFCS is a computer-operated fire control system that provides automatic acquisition and tracking of a designated target, generates launcher and missile orders, and in the automatic mode initiates the firing command when the target becomes engageable. Although most of the NSSMS operations are carried out under automatic or semi-automatic conditions, the GMFCS permits operator intervention and override at any time. The GMLS is a rapid-reaction, lightweight launching system that provides on-mount stowage and launch capability of up to eight missiles. The GMLS responds to launcher position commands, missile orders, and control commands issued by GMFCS. The NSSMS employs AIM/RIM-7 Sparrow III series, surface-to-air/surface-to-surface semi-active homing missiles. The RIM-7 version is commonly referred to as SEASPARROW. The missile utilizes the energy reflected from the target and from rear reference RF (transmitted from the director system) for developing missile wing movement orders enabling target intercept.

The NATO SEASPARROW Surface Missile System (NSSMS) Mk 57 Mod 6 is a medium-range, rapid-reaction system uses a semi-active homing missile. This version of the NSSMS is a restructured design utilizing the Reflected Memory Local Area Network fiber optic cable. The NSSMS Mod 6 consists of a Tracking Illuminator System (TIS) Mk 9 Mod 0 and a Guided Missile Launching System (GMLS) Mk 29 Mod 2. The TIS is a computer-operated fire control system that provides automatic acquisition and tracking of a designated target, generates launcher and missile orders, and in the automatic mode initiates the firing command when the target becomes engageable. Although most of the NSSMS operations are carried out under automatic or semi-automatic conditions, the TIS

permits operator intervention and override at any time. The GMLS is a rapid-reaction, lightweight launching system that provides on-mount stowage and launch capability of up to eight missiles. The GMLS responds to launcher position commands, missile orders, and control commands issued by TIS. The NSSMS employs Evolved SeaSparrow Missile (ESSM) or RIM-7M/P/R, which is a high velocity and extremely agile missile with semi-active radar homing.

Originally developed by Sperry and the U.S. Navy, *Sparrow*'s later versions were developed and produced by Raytheon Co. and General Dynamics.

The Evolved Sea Sparrow Missile (ESSM) is a short range missile intended to provide self-protection for surface ships. It is expected to be available to the fleet around 2002. It will provide each ship with the capability to engage a variety of antiship cruise missiles (ASCMs) and aircraft to support self defense. It will be more capable against low observable highly maneuverable missiles, have longer range, and can make flight corrections via radar and midcourse uplinks. ESSM is a coordinated effort with numerous nations in the North Atlantic Treaty Organization (NATO). This coordinated effort allows all NATO countries to have the same self defense capability and at the same time, reduce the cost to each country associated with developing and testing new systems.

On Aegis ships, ESSM will be launched from the MK 41 Vertical Launch System, requiring a thrust vector control system on the ESSM rocket. On non-Aegis ships (aircraft carriers, amphibious assault ships, other surface combatants), it will be fired from other launch systems. ESSM uses an 8 inch diameter forebody that includes a modified guidance section from the in-service RIM-7P Sea Sparrow. The guidance section, which includes a radome-protected antenna for semiactive homing, attaches to a new warhead section. The forebody is attached to a new 10 inch diameter rocket motor which provides higher thrust for longer duration than predecessor Sea Sparrow missiles. ESSM will use skid-to-turn steering (tail control) whereas earlier Sea Sparrows were wing-controlled. ESSM will retain capability of the RIM-7P missile but will also have capability against maneuvering anti-ship missiles. ESSM is being developed as a multinational cooperative effort with several allied nations.

The new RIM-7P software features advanced guidance algorithims that enable Seasparrow to counter the most formidable threats. The missile’s Improved Low Altitude Guidance (LAG) mode makes the RIM-7P exceptionally effective against very low altitude threats, such as sea skimming cruise missiles. In addition, the missile has proven to be highly effective in stressing Electronic Attack (EA) environments.

A Jet Vane Control (JVC) unit allows the RIM-7P to be vertically launched. The JVC unit rotates the missile immediately after it has cleared a ship’s superstructure, cancels the missile’s initial upward velocity, and controls transition to the initial intercept path. Once the seeker is pointing toward a target, the JVC is jettisoned. Vertical launch capability provides quick-reaction, 360-degree defense and eliminates trainable firing restrictions and time consuming slew requirements.

Specifications

Primary Function	Air-to-air and surface-to-air radar-guided missile
Contractors	Raytheon Co. and General Dynamics
Power Plant	Hercules MK-58 solid-propellant rocket motor
Thrust	Classified
Speed	More than 2,660 mph (4,256 kph)
Range	More than 30 nautical miles (approximately 55 km) [Maximum Range = 6 nm according to other sources] Minimum Range - 1600 yards Director Lock-on Range - 50 nautical miles
Length	12 feet (3.64 meters)
Diameter	8 inches (20.3 cm)
Wingspan	3 feet 4 inches (one meter)
Warhead	Annular blast fragmentation warhead, 90 pounds (40.5 kg) Proximity fuzed, continuous expanding rod, with a 27 ft. kill radius
fire control systems	MK 91
Launch Platform (Launcher)	MK 29 Mod 1.
Launch Weight	Approximately 500 pounds (225 kg)
Guidance System	Raytheon semi-active on continuous wave or pulsed Doppler radar energy
Date Deployed	1976
Unit Cost	$165,400
Inventory	Classified














RIM-66 / RIM-67 Standard Missile

The Standard Missile-2 (SM-2) is the Navy’s primary surface-to-air fleet defense weapon. The currently deployed SM-2 Block II/III/IIIA configurations are all-weather, ship-launched medium-range fleet air defense missiles derived from the SM-1 (RIM-GGB), which is still in the fleet. SM-2 employs an electronic countermeasures-resistant monopulse receiver for semi-active radar terminal guidance and inertial midcourse guidance capable of receiving midcourse command updates from the shipboard fire control system. SM-2 is launched from the Mk 41 Vertical Launching System (VLS) and the Mk 26 Guided Missile Launching System (GMLS). SM-2 continues to evolve to counter expanding threat capabilities, and improvements in advanced high and low-altitude threat interception, particularly in stressing electronic countermeasures (ECM) environments, are being implemented through modular changes to the missile sections.

The Standard Missile was produced in two major types, the SM-1 MR/SM-2 (medium range) and the SM-2 (extended range). It is one of the most reliable in the Navy's inventory. Used against missiles, aircraft and ships, it first came into the fleet more than a decade ago. It replaced *Terrier* and *Tartar* missiles and is part of the weapons suit of more than 100 Navy ships. The SM-2 (MR) is a medium range defense weapon for *Ticonderoga*-class AEGIS cruisers, *Arleigh Burke*-class AEGIS destroyers, *California* and *Virginia*-class nuclear cruisers and *Kidd*-class destroyers with NTU conversions. *Oliver Hazard Perry*-class frigates use the SM-1 MR.

The SM-2 is a solid propellant-fueled, tail-controlled, surface to air missile fired by surface ships. Designed to counter high-speed, high-altitude anti-ship cruise missiles (ASCMs) in an advanced ECM environment, its primary mode of target engagement uses mid-course guidance with radar illumination of the target by the ship for missile homing during the terminal phase. The SM-2 can also be used against surface targets. SM-2 Blocks II through IV are long-range interceptors that provide protection against aircraft and antiship missiles, thereby expanding the battlespace.

The **Block II** version of SM-2 includes a signal processor to provide less vulnerability to ECM, an improved fuze and focused-blast fragment warhead to provide better kill probability against smaller, harder targets, and new propulsion for higher velocities and maneuverability.

A **Block III** version of SM-2 provides improved capability against low altitude targets.

Block IIIA, a modification to this version, extends capability to even lower altitudes. RIM-66C Block IIIA includes a new warhead that imparts greater velocity to warhead fragments in the direction of the target.

Block IIIB is the next step in the continuing evolution of the Standard Missile family, incorporating an infrared (IR) guidance mode capability developed in Missile Homing Improvement Program (MHIP) with the radio frequency (RF) semi-active guidance system of the proven SM-2 Block IIIA. The MHIP dual-mode RF/IR guidance capability is being incorporated to counter a specific fielded and proliferating electronic warfare systems in existing aircraft and ASCM threats. OPEVAL of SM-2 Block IIIB was conducted during April 1996, with missile firings by an Aegis cruiser that was completing workup training for deployment. Based on OPEVAL results, SM-2 Block IIIB is operationally effective and suitable.

These SM-2 versions are provided as medium range (MR) rounds that can be fired from Aegis rail launchers, Aegis vertical launch systems (VLS), and Tartar rail launchers.

The **Block IV** version was developed to provide extended range [ER], improved cross-range and higher altitude capability for Aegis VLS ships, as well as improved performance against low RCS targets and against complex ECM. The SM-2 Block IV is a kinematic improvement beyond the SM-2 Block III, incorporating a thrust-vector controlled booster, a more robust airframe, and guidance and control modifications for improved altitude/range/cross-range coverage against high-performance, low radar cross-section threats in a stressing electronic countermeasures (ECM) environment. In addition to providing significant increases in ship area defense capability, the SM-2 Block IV is the developmental stepping stone to SM-2 Block IVA, the Navy's Area Theater Ballistic Missile Defense (TBMD) missile. The Standard Missile-2 Block IV program experienced considerable development problems and schedule delays in 1991. Primarily due to booster problems, the first successful propulsion test vehicle firing was been delayed more than a year. As a result, the initial production decision, once scheduled for the middle of fiscal year 1991, slipped until December 1992, the first quarter of fiscal year 1993. Since only early IOT&E of SM-2 Block IV was conducted to support its LRIP decision, its capability was never fully determined (capability was not demonstrated against ASCM threat representative, maneuvering targets nor against low altitude, low Doppler targets). That is, the Block IV program was restructured, with the intention to proceed to DT&E/OT&E to support a full production decision if technical problems are encountered with development of the SM-2 Block IVA that preclude its retention of Block IV capability (never fully determined) against anti-air warfare threats.

Block IVA adds a dual-mode radio frequency/infrared (RF/IR) sensor, an upgraded ordnance package, and autopilot/control enhancements to the SM-2 Block IV The SM-2 Block IVA missile uses the TBMD-modified Aegis Weapon System on board Aegis cruisers and destroyers to track and

engage TBMs, enhancing U.S. littoral warfare capability by allowing Aegis ships to provide TBMD for ships at sea and ground force embarkation areas ashore, without the constraints imposed by sealift or airlift. The SM-2 Block IVA upgrade is being developed to provide capability against theater ballistic missiles, although it is planned to retain capability against anti-air warfare threats. A System Design Review for SM-2 Block IVA was conducted in December 1993 and a Risk Reduction Flight Demonstration (RRFD) program was initiated in FY 1994. An Environmental Test Round (ETR-2A) was successfully launched in the summer 1996. On January 24, 1997, the Navy successfully demonstrated a Theater Ballistic Missile Defense capability when a ballistic missile target was shot from the sky for the first time using a new version of the *Standard* missile family. This Developmental Test Round (DTR-1) demonstrated the imaging infrared seeker and the capability to intercept a TBM.

Full production approvals for SM-2 Blocks have been as follows: Block II was approved in December 1986; Block III in June 1988; Block IIIA in February 1992; and Block IIIB in September 1996, following the OPEVAL summarized below. Block IV was approved for LRIP in May 1995, but further development and procurement were deferred, depending on development of the Block IVA missile, the interceptor for the Navy Area TBMD program, and Block IVA retention of Block IV capability against anti-air warfare threats. On April 16, 1999 Raytheon Systems Company, Tucson AZ, was awarded a not-to-exceed $135,236,224 fixed-price with award-fee, letter contract for the procurement of 71 SM-2 Block IIIB (AUR's), 63 SM-2 Block IIIB ORDALT kits to upgrade SM-2 Block III missiles to SM-2 Block IIIB, 43 SM-2 Block IV AUR's, 100 AN/DKT-71A telemetric data transmitting sets, section level spares, shipping containers and handling equipment.

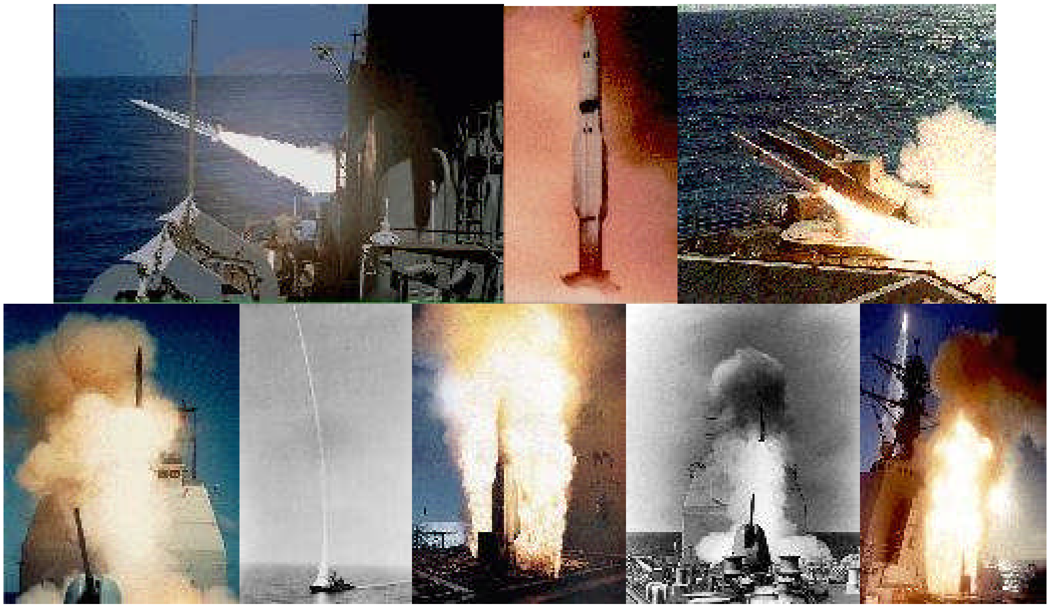
Specifications

	SM-1 Medium Range	SM-2 Medium Range	SM-1 Extended Range	SM-2 Extended Range
Primary Function	Surface to air missile			
Contractors	• Hughes Missile Systems Company (formerly General Dynamics' Ponoma Division, sold to Hughes in 1992) Ponoma Division; • Raytheon Motorola; • Morton-Thiokol; • Aerojet General • and others			
Unit cost	$402,500	$421,400	$409,000	
Power plant	Single-stage, Dual thrust,		Two-stage, solid-fuel	

	solid fuel rocket		rocket; sustainer motor and booster motor
Length	14 feet, 7 inches (4.41 meters)		26.2 feet (7.9 meters)
Diameter	13.5 inches (34.3 cm)		
Wing Span	3 feet 6 inches (1.08 meters)		5 feet 2 inches (1.6 meters)
Weight	1,100 pounds (495 kg)	1,380 pounds (621 kg)	2,980 pounds (1341 kg)
Range	15-20 nautical miles (17-23 statute miles)	40-90 nautical miles (46-104 statute miles)	65-100 nautical miles (75-115 statute miles)
Guidance system	Semi-active radar homing		Inertial/semi-active radar homing
Warhead	Proximity fuse, high explosive		
Date Deployed	1970	1981	1981
Launch Systems			
Launch Platforms			





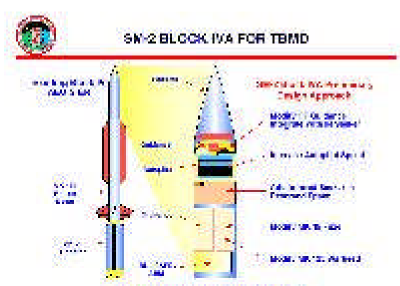
Navy Area Defense (NAD)

The Navy Area Defense (NAD) system consists of Standard Missile-2 Block IVA interceptors deployed aboard Aegis ships. The capability provided by this system has the advantage of being able to be brought into theater quickly without having to put forces on land. The Standard family of missiles is one of the most reliable in the Navy's inventory. A weapon which can be used against missiles, aircraft, and ships, it first came into the fleet more than two decades ago, replacing the Terrier and Tartar. On January 24, 1997, the Navy successfully demonstrated a Theater Ballistic Missile Defense capability when a ballistic missile target was shot from the sky for the first time using a new version of the Standard missile family.
DOD added about $120 million to this program in the FY97 budget. These funds covered delays in risk-reduction flights and adjusted cost estimates for test targets and lethality efforts. This allowed us to proceed expeditiously with the EMD program and LRIP missile procurement.

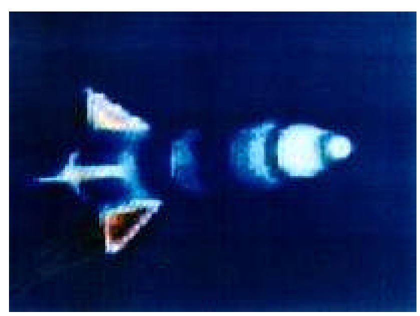
To demonstrate the capabilities of the NAD system, in January 1997, a target simulating a threat ballistic missile was successfully engaged. In February 1997, the NAD program was reviewed during the Defense Acquisition Board (DAB) Readiness Meeting (DRM), which approved the program to enter into the EMD phase. This put NAD on the path to have a User Operational Evaluation System (UOES) capability on two cruisers late in fiscal year 1999, with the FUE in the fourth quarter of fiscal year 2001.

The Control Test Vehicle-1 (CTV-1) flight test in mid-2000 was the first of five planned flight tests at White Sands. These tests do not involve target intercepts. As of mid-2000 the program was scheduled for first unit equipped in 2003.

SM-2 Block IVA



SM-2 Block IVA
Design Enhancements (43K)



Infrared View of
Incoming Lance Target (23K)

Standard Missile-2 Block IV Launch at White Sands (53K)

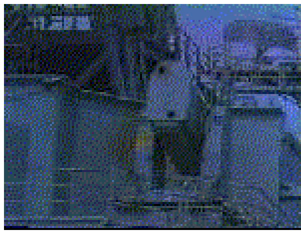
AEGIS Cruiser Launch of Standard Missile-2 Block IV (33K)

AEGIS Cruiser Launch of Standard Missile-2 Block IV (60K)

Contractor:

Hughes Missile Systems Company (formerly General Dynamics' Ponoma Division, sold to Hughes in 1992) Ponoma Division; Raytheon Motorola; Morton-Thiokol; Aerojet General and others

RIM-116 RAM Rolling Airframe Missile



The RAM program is designed to provide surface ships with an effective, low-cost, lightweight, self-defense system which will provide an improved capability to engage and defeat incoming antiship cruise missiles (ASCMs). RAM is a joint United States and German venture to design an effective, low cost, lightweight quick-reaction, self-defense system which will increase the survivability of otherwise undefended ships. It is a 5 inch missile that utilizes SIDEWINDER technology for the warhead and rocket motor, and the STINGER missile's seeker. Cueing is provided by the ship's ESM suite or radar. The MK-31 RAM Guided Missile Weapon System (GMWS) is defined as the MK-49 Guided Missile Launching System (GMLS) and the MK-44 Guided Missile Round Pack (GMRP).

The RAM Block 0 has a five-inch diameter airframe that rolls in flight and dual mode, passive radio frequency/infrared (RF/IR) guidance. Initial homing for RAM Block 0 is in RF, using an ASCM's RF seeker emissions. If the ASCM's IR radiation is acquired, RAM transitions to IR guidance.

Operational Evaluation (OPEVAL) of RAM Block 0 was conducted from January to April 1990. It was assessed to be potentially operationally effective and potentially operationally suitable, but there were shortfalls in its ability to handle, under all environmental and tactical conditions, the full spectrum of threats. In April 1993, a decision was made to pursue rectification of OPEVAL deficiencies by implementing a block upgrade. RAM Block 1 is the upgraded missile.

Effective against a wide spectrum of existing threats, the RAM Block 1 IR upgrade incorporates a new IR "all-the-way-homing" guidance mode to improve AW performance against evolving passive and active ASCMs. The Block 1 missile retains all capabilities of the Block 0 missile while adding two guidance modes, IR only and IR Dual Mode Enable (IRDM). The IR only mode guides on the IR signature of the ASCM. The IRDM will guide on the IR signature of the ASCM while retaining the capability of utilizing RF guidance if the ASCM RF signature becomes adequate to guide on. RAM Block I can be launched in an IR all-the-way mode, as well as the dual mode (passive RF, followed by passive IR) used by Block 0.
The launching system and missiles comprise the weapon system.
RAM weapon systems are integrated with the AN/SWY-2 combat system on certain ships and as part of the Ship Self Defense System (SSDS) on other ships (LSD-41 class ships at this time). The AN/SWY-2 is comprised of the weapon system and the combat direction system. The combat direction system employs the existing Mk 23 target

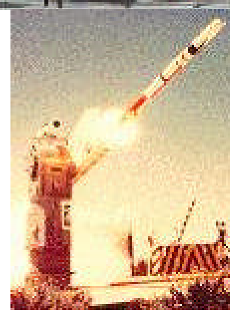
acquisition system (TAS) radar and the AN/SLQ-32(V) electronic warfare support sensor together with threat evaluation and weapons assignment software resident in the Mk 23 TAS to accomplish threat detection, correlation, evaluation, and engagement. With SSDS, RAM is part of the engagement suite. For example, on LSD 41-class ships, a typical SSDS engagement suite includes RAM, the PHALANX Close-In Weapon System Block 1A, and the decoy launch system. SSDS further integrates the AN/SPS-49(V)1 radar with the medium PRF upgrade, the AN/SPS-67 surface search radar, the AN/SLQ-32(V) sensor, and the CIWS search radar. RAM is installed in all five Tarawa (LHA-1)-class amphibious assault ships; LHD 1, 3, 5, and 6; DD-987, and LSD-48. Block 0 missiles and launchers are in production and on schedule, and the missile had successful intercepts in 62 of 64 production-proofing and ship qualification tests. The first fleet firing of the RAM occurred in October 1995 from the USS Peleliu (LHA-5). A successful preliminary design review of the Block 1 IR upgrade was conducted in September 1995. Flight tests of the missile are being conducted during Engineering and Manufacturing Development, prior to authorizing Low-Rate Initial Production (LRIP). Milestone III was achieved in FY 1998, to be followed by IOC in FY 1999.

Specifications

Primary Function	Surface-to-air missile
Contractor	Hughes Missile Systems Co. Tucson, AZ
Power Plant	
Thrust	
Speed	
Range	
Length	
Diameter	
Finspan	
Warhead	
Launch Weight	
Guidance System	
Status	Full-rate production (Block 0) FY94 Full-rate production (Block I) FY99
Costs	Total program cost (TY$) $1,709.4M Average unit cost Block 0 $0.273M Average unit cost Block 1 $0.444M
Inventory Objective	1,310 Block 0 missiles 620 Block I missiles 154 Launchers The Navy has stated a requirement for 1,600 RAMS

and 115 launchers to equip 74 ships.
Congress approved funds for 230 RAMS in FY 1996; the Navy requested 125 RAMS in FY 1997, 100 in FY 1998, and 200 missiles in FY 1999.



BGM-109 Tomahawk

Tomahawk is an all-weather submarine or ship-launched land-attack cruise missile. After launch, a solid propellant propels the missile until a small turbofan engine takes over for the cruise portion of flight. Tomahawk is a highly survivable weapon. Radar detection is difficult because of the missile's small cross-section, low altitude flight. Similarly, infrared detection is difficult because the turbofan engine emits little heat. Systems include Global Positioning System (GPS) receiver; an upgrade of the optical Digital Scene Matching Area Correlation (DSMAC) system; Time of Arrival (TOA) control, and improved 402 turbo engines.

The Tomahawk land-attack cruise missile has been used to attack a variety of fixed targets, including air defense and communications sites, often in high-threat environments. The land attack version of Tomahawk has inertial and terrain contour matching (TERCOM) radar guidance. The TERCOM radar uses a stored map reference to compare with the actual terrain to determine the missile's position. If necessary, a course correction is then made to place the missile on course to the target. Terminal guidance in the target area is provided by the optical Digital Scene Matching Area Correlation (DSMAC) system, which compares a stored image of target with the actual target image.

The Tomahawk missile provides a long-range, highly survivable, unmanned land attack weapon system capable of pinpoint accuracy. The Surface Navy's deep strike capability

resides in the Tomahawk missile system - the proven weapon of choice for contingency missions.

Tomahawk's operational environment is changing significantly. The first operational design involved global warfare using conventional Tomahawk Land Attack Missiles (TLAM) against known, fixed, non-hardened targets. The strategic assumptions underlying this environment continue to change. Tomahawk Weapon System (TWS) capability is evolving into major systems with expanding capabilities. Today, Tomahawk is able to respond to rapidly developing scenarios and attack emerging land-based targets. A more diverse threat coupled with a smaller U.S. force structure place an absolute premium on system flexibility and responsiveness.

The projected operational environment for Tomahawk is now characterized by scenarios in which the U.S. Navy will most likely be called upon to defend U.S. interests in regional conflicts, in crisis response, or to execute national policy. Tomahawk will operate from littoral seas as an integral part of joint forces.

During the critical early days of a regional conflict, Tomahawk, in conjunction with other land attack systems and tactical aircraft, denies or delays forward movement of enemy forces, neutralize the enemy's ability to conduct air operations, and suppress enemy air defenses. In addition, Tomahawk attacks high value targets such as electrical generating facilities, command and control nodes, and weapons assembly/storage facilities. Thus, making Tomahawk the weapon of choice to strike reinforced, hardened targets.

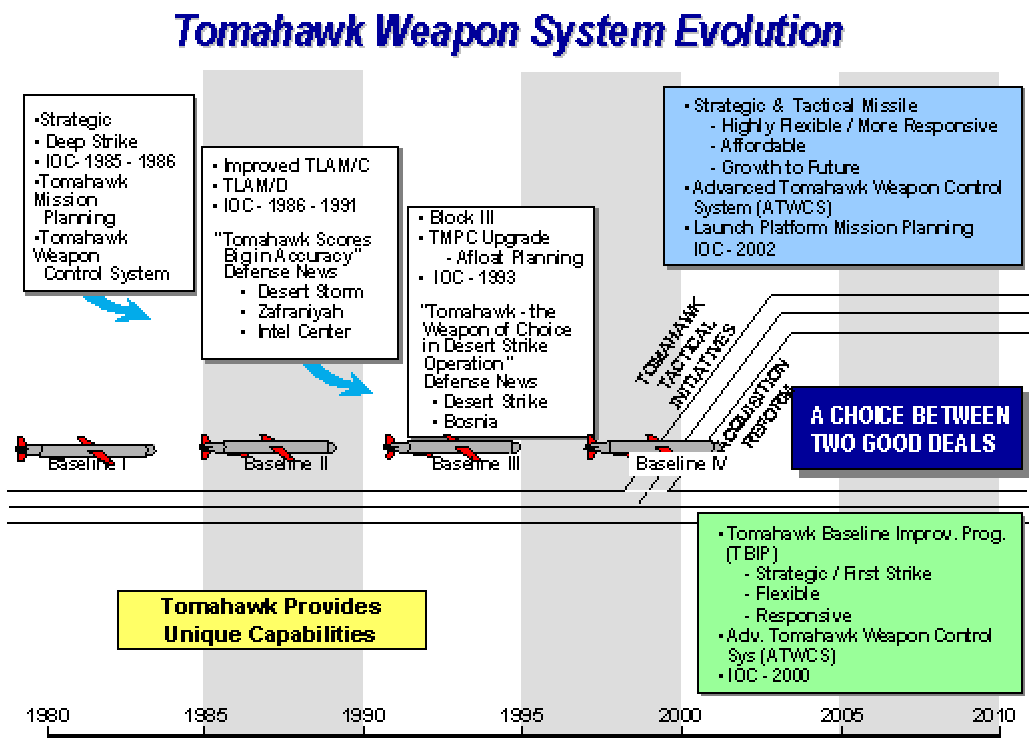
The Tomahawk Weapon System (TWS) is comprised of four major components: Tomahawk Missile, Theater Mission Planning Center (TMPC)/Afloat Planning System (APS), Tomahawk Weapon Control System (TWCS) for surface ships, and Combat Control System (CCS) for submarines.

Ships and submarines have different weapon control systems (WCSs). A vertical launching system (VLS) accommodates missile stowage and launch on ships. On all attack submarines, missiles are launched from torpedo tubes (with stowage in the torpedo room); in addition, some attack submarines have VLS located forward, external to the pressure hull, which will handle both stowage and launch.

The Fire Control Systems (FCS) on both ships and submarines perform communications management, database management, engagement planning, and launch control functions. These systems provide the interface between the missile and FCS for missile initialization and launch as well as environmental protection. The FCS supporting the ship is TWCS of ATWCS (AN/SWG-3). The FCS on submarines is the CCS MK1, CCS Mk2, or AN/BSY-1.

Unified Commanders develop contingency plans in response to developing strategic situations to achieve National Command Authority directed goals. The Unified Commander passes tasking for TLAM mission development to a Cruise Missile Support Activity (CMSA) for overland mission planning. The National Imagery and Mapping

Agency (NIMA) provides the necessary databases for planning. Targets and maps are generated for TERCOM and DSMAC. Threat databases are provided for missile attrition analysis. Unified, Joint, and Battle Group (BG) Commanders direct the deployment and employment of the mission. Strike Planners select, task and coordinate TLAM strikes. The Launch platform FCS prepares and executes the TLAM mission. The launch platform launches the missile. The missile boosts and transitions to cruise flight, then navigates on the planned route. During flight, the missile will navigate using TERCOM and DSMAC and GPS (Block III). Enroute, some missiles may also execute a Precision Strike Tomahawk Mission (PST) transmitting its status back to a ground station via satellite communication. The missile executes its planned terminal maneuver and for TLAM-C hits a single aimpoint and for TLAM-D, single or multiple targets.



Tomahawk Variants

The Tomahawk is a mature missile weapons system with Block II and III, C (unitary warhead) and D (bomblet dispersion) versions in fleet use. These two variants of Tomahawk cruise missile are distinguished by their warhead; TLAM-C has a conventional unitary warhead, and TLAM-D has a conventional submunitions (dispense bomblets) warhead. Both are identical in appearance, but different in capabilities. The missile concept is one of a wooden round. The missile is delivered to ships and submarines as an all-up-round (AUR), which includes the missile that flies the mission, the booster that starts its flight, and the container (canister for ships and capsule for submarines) that protects it during transportation, storage and stowage, and acts as a launch tube.

Operational evaluation to support a milestone III full rate production decision on the TOMAHAWK missile began in January 1981. This OPEVAL was conducted in six phases. The first three phases all involved testing of the submarine launched TOMAHAWK missiles. The sub launched antiship version (TASM), conventional land attack missile (TLAM/C), and nuclear land attack variant (TLAM/A) were tested from January 1981 to October 1983. The last three phases tested the ship launched variants. The ship launched variants were tested from December 1983 to March 1985. In all phases , the AUR was determined to be potentially operationally effective and potentially operationally suitable, and full rate production was recommended. In April of 1988 the OPEVAL of the conventional land attack submunitions missile (TLAM/D) was tested. The missile was determined to be potentially operationally effective and potentially operationally suitable, with limited fleet introduction recommended.

As missile improvements were made, follow on test and evaluation continued. BLK II improvements were made and tested with all variants in July 1987 through September 1987. Some of these improvements included a TASM improved sea skimming variant, an improved booster rocket, cruise missile radar altimeter, and the Digital Scene Matching Area Corellator (DSMAC) Blk II. In October of 1990, the OPEVAL of the Blk III missile began. The Blk III was the first time GPS was used to aid missile guidance. The testing was performed on both surface and subsurface units under various environmental conditions, continuing through July 1994. Both conventional variants (TLAM/C and D) were tested and determined to be operationally effective and operationally suitable, with full fleet introduction recommended.

The TOMAHAWK missile performance testing is an ongoing, five year study of TLAM performance which began in 1995. The testing is run concurrently with the Operational Test Launch (OTL) program. The objective of the program is to verify, in a statistically significant manner, that missile performance, accuracy, and reliability meet operational requirements and thresholds. The program tests approximately eight missiles each year, two TLAM/N and six TLAM/C and D missiles. The testing emphasizes operationally realistic test scenarios, including battle group operations, for missiles launched from TOMAHAWK capable Block II and Block III surface ships and submarines. Full end to end testing is completed with every mission.

Tomahawk Block III Since the Gulf War, the Navy has improved its Tomahawk missile's operational responsiveness, target penetration, range, and accuracy. It has added global positioning system guidance and redesigned the warhead and engine in the missile's block III configuration that entered service in March 1993. The Tomahawk TLAM Block III system upgrade incorporated jam-resistant Global Positioning System (GPS) system receivers; provided a smaller, lighter warhead, extended range, Time of Arrival, and improved accuracy for low contrast matching of Digital Scene Matching Area Correlator. With GPS, TLAM route planning is not constrained by terrain features, and mission planning time is reduced. China Lake designed, developed, and qualified the WDU-36 warhead in 48 months to meet evolving Tomahawk requirements of insensitive munitions ordnance compliance and range enhancement, while maintaining or enhancing ordnance effectiveness. The WDU-36 uses a new warhead material based upon prior

China Lake warhead technology investigations, PBXN-107 explosive, the FMU-148 fuze (developed and qualified for this application), and the BBU-47 fuze booster (developed and qualified using the new PBXN-7 explosive). Block III was first used in the September 1995 Bosnia strike (Deliberate Force) and a year later in the Iraq strike (Desert Strike).

Tomahawk Block IV Phase I The Navy's premier strike weapon for the next generation is the Block IV Phase I Tomahawk. Current plans call for 1,253 Block IV missiles to be produced by remanufacturing currently bunkered TASMs (Tomahawk antiship variant) and upgrading Block II missiles to Block IV. Following extensive analysis of major regional conflict (MRC) Tomahawk usage and the resupply and support levels associated with it, OPNAV, in concert with fleet CINCs, developed an acquisition objective of 3,440 Block III and IV Tomahawk missiles through the completion of the Block IV program.

Tomahawk Baseline Improvement Program (TBIP) The Navy will upgrade or remanufacture existing Tomahawk missiles with (1) GPS and an inertial navigation system to guide the missile throughout the mission and (2) a forward-looking terminal sensor to autonomously attack targets. These missiles are expected to enter service around 2000. This Tomahawk Baseline Improvement Program (TBIP) development provides a comprehensive baseline upgrade to the Tomahawk Weapon System to improve system flexibility, responsiveness accuracy and lethality. Essential elements of the TBIP include upgrades to the guidance, navigation, control, and mission computer systems along with the associated command and control systems and weapons control systems. TBIP will provide a single variant missile, the Tomahawk Multi-Mission Missile that is capable of attacking sea- and land-based targets in near real time. TBIP will also enhance its hard target penetrating capability beyond current weapons systems thus increasing the target set. TBIP will provide UHF SATCOM and man-in-the-loop data link to enable missile to receive in-flight targeting updates, to transfer health and status messages and to broadcast Battle Damage Indication (BDI). The Advanced Tomahawk Weapons Control System (ATWCS) and Tomahawk Baseline Improvement Program will provide a quick reaction response capability, real time target and aimpoint selection, autonomous terminal prosecution of the target and improve strike planning, coordination, mission tasking and lethality.

Tomahawk Block IV Phase II Future deep-strike requirements are in review and focus on technological advancements and cost reduction. Follow-on Tomahawk Block developments and replacement systems also are being reviewed. An antiarmor variant with a real-time targeting system for moving targets, using either Brilliant Antiarmor Technology or Search and Destroy Armor submunitions, is a possibility. Both submunition options leverage off U.S. Army developmental programs, reducing program costs.

TacticalTomahawk would add the capability to reprogram the missile while in-flight to strike any of 15 preprogrammed alternate targets or redirect the missile to any Global Positioning System (GPS) target coordinates. It also would be able to loiter over a target area for some hours, and with its on-board TV camera, would allow the warfighting

commanders to assess battle damage of the target, and, if necessary redirect the missile to any other target. Tactical Tomahawk would permit mission planning aboard cruisers, destroyers and attack submarines for quick reaction GPS missions. If approved by Congress, the next generation of long-range Tomahawk cruise missiles would cost less than $575,000 each, half the estimated cost of $1.1 - 1.4 million for the currently planned Block IV model. The cost savings and increased capability comes from eliminating many older internal systems and components built into the model currently in the Fleet. In addition, streamlined production techniques and modular components would combine to lower the cost. Tactical Tomahawk is expected to reach the Fleet by 2002 if the production proposal is approved by Congress. On 27 May 1999 Raytheon was awarded a $25,829,379 undefinitized cost-plus-incentive-fee/cost-plus-fixed-fee, ceiling amount contract for the modification of the Tactical Tomahawk missile to the Tactical Tomahawk Penetrator Variant configuration as part of the Second Counter-Proliferation Advanced Concept Technology Demonstration. The Tactical Tomahawk missile will be modified to incorporate the government-furnished penetrator warhead and the hard-target smart fuze. Four Tactical Tomahawk Penetrator Variant missiles will be assembled to conduct the advanced concept technology demonstration testing. Work will be performed in Tucson AZ and is expected to be completed by March 2003.
Tomahawk Block V Also under consideration is a proposed Block V missile that would pioneer a new production method using modular design and construction technology to dramatically lower unit costs. Payload and guidance packages would be buyer-selectable based on use and budget.

Tomahawk Inventory

Inventory buildup of Tomahawk missiles will be achieved through manufacture of a new variant of the Tomahawk, the U/RGM-109E. Following extensive analysis on Major Regional Conflict (MRC) operational plans, Tomahawk usage and the resupply and support levels associated with them, OPNAV in concert with fleet CINCS established a requirement of 3440 missiles by FY06. The Navy currently has over 2500 BLOCK II and BLOCK III missiles. The future conventional Tomahawk inventory will be composed of BLOCK III TLAM C/D and Tactical Tomahawk missiles. BLOCK III TLAM C/D missiles will continue to represent the majority of Tomahawk inventory even after introduction of the Tactical Tomahawk missile, resulting in one-third Tactical Tomahawk, two-thirds BLOCK III split in conventional land strike missiles.

In the early 1990s there were approximately 2,500 Tomahawks in inventory. That number was reduced to about 2,000 with the use of 330 during the 4-day bombing in Operation Desert Fox in December 1998, and the use of over 160 by the Navy in Kosovo by mid-April 1999. By one estimate, the cost of restarting the Tomahawk production line would be $40 million, and it would take 2 1/2 years before new missiles would come off that line, although the Navy is seeking $113 million to remanufacture 324 older model Tomahawks under the Tomahawk Baseline Improvement Program (TBIP).

On 30 April 1999 the US Department of Defense announced the possible sale to the Government of the United Kingdom of 30 conventionally armed TOMAHAWK BLOCK

IIIC Land Attack Missiles (TLAM), containers, engineering technical assistance, spare and repair parts, and other related elements of logistics support. The estimated cost is $100 million. The additional 30 Tomahawk sea-launched cruise missiles are in addition to an original order for 65, as replacements for those fired in the Allied Force campaign by the submarine HMS Splendid. The United Kingdom needed these missiles to augment its present operational inventory and to enhance its submarine launched capability. The United Kingdom, which already has TOMAHAWK missiles in its inventory, will have no difficulty absorbing these additional missiles.

Tomahawk Operational Use

Tomahawk was used extensively during Desert Storm in 1991, in Iraq in January and June 1993, in Bosnia (Deliberate Force) in 1995 and in Iraq (Desert Strike) in 1996. Four hundred Block II and Block III missiles were fired on five separate occasions.

Two submarines and a number of surface ships fired Tomahawk cruise missiles during the Gulf War. According to initial US Navy reports, of 297 attempted cruise missile launches, 290 missiles fired and 242 Tomahawks hit their targets. But TLAM performance in Desert Storm was well below the impression conveyed in DOD's report to the Congress, as well as in internal DOD estimates. During Desert Storm, a TLAM mission was loaded 307 times into a particular missile for launch from a Navy ship or submarine. Of those 307, 19 experienced prelaunch problems. Ten of the 19 problems were only temporary, thus these missile were either launched at a later time or returned to inventory. Of the 288 actual launches, 6 suffered boost failures and did not transition to cruise. Despite initial strong positive claims made for TLAM performance in Desert Storm, analysis of TLAM effectiveness was complicated by problematic bomb damage assessment data. The relatively flat, featureless, desert terrain in the theater made it difficult for the Defense Mapping Agency to produce usable TERCOM ingress routes, and TLAM demonstrated limitations in range, mission planning, lethality, and effectiveness against hard targets and targets capable of mobility.

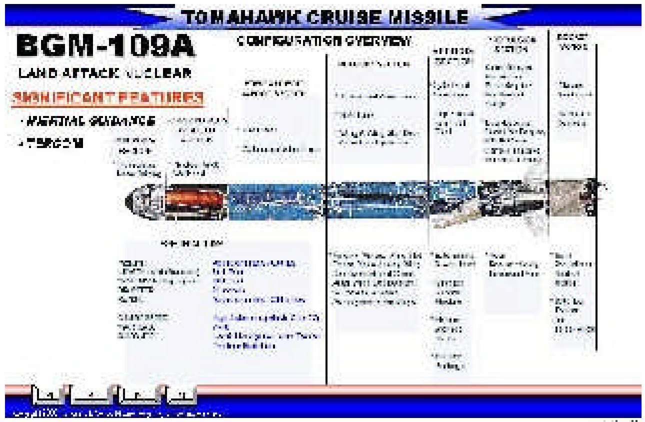
The Gulf War and subsequent contingency operations, including the September 1996 attacks on Iraqi military installations, demonstrated that long-range missiles can carry out some of the missions of strike aircraft while they reduce the risk of pilot losses and aircraft attrition.

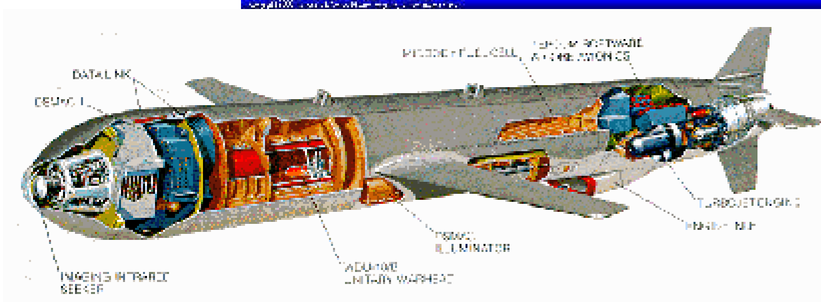
Although the number of ships (including attack submarines) capable of firing the Tomahawk grew only slightly--from 112 to 119--between 1991 and 1996, the Navy's overall ability to fire these land-attack missiles has grown considerably. This is because a greater number of the ships capable of firing the missile are now surface ships and surface ships are able to carry more Tomahawks than submarines. As of the beginning of 1996 the US Navy had 140 Tomahawk-capable ships with 6,266 launchers), of which there are 72 SSN's (696 launchers) and 70 surface ships (5,570 launchers). There were over 4,000 Tomahawk cruise missiles in the inventory in 1996.

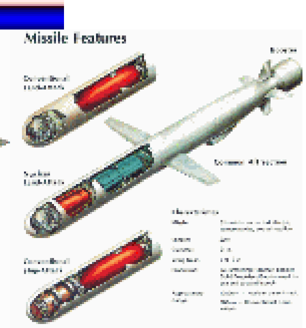
Block III, with its improved accuracy and stand alone GPS guidance capability, was first used in the September 1995 Bosnia strike (Deliberate Force) and again in the September 1996 Iraq strike (Desert Strike). Success rates for both strikes were above 90%. In all, Tomahawks firing power shows a greater than 85% success rate

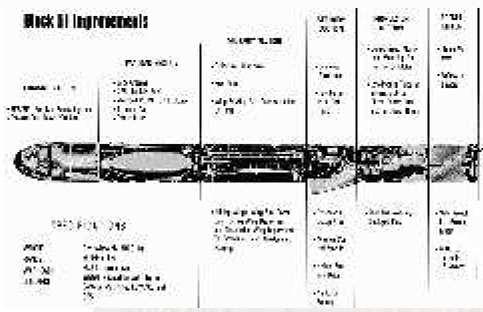
Specifications

Primary Function:	Long-range subsonic cruise missile for attacking land targets.
Contractor:	Hughes Missile Systems Co., Tucson, Ariz.
Power Plant:	Williams International F107-WR-402 cruise turbo-fan engine; solid-fuel booster
Length:	18 feet 3 inches (5.56 meters); with booster: 20 feet 6 inches (6.25 meters)
Weight:	2,650 pounds (1192.5 kg); 3,200 pounds (1440 kg) with booster
Diameter:	20.4 inches (51.81 cm)
Wing Span:	8 feet 9 inches (2.67 meters)
Range:	Land attack, conventional warhead: 600 nautical miles (690 statute miles, 1104 km)
Speed:	Subsonic - about 550 mph (880 km/h)
Guidance System:	Inertial and TERCOM
Warheads:	Conventional: 1,000 pounds Bullpup, or Conventional submunitions dispenser with combined effect bomblets, or WDU-36 warhead w/ PBXN-107 explosive & FMU-148 fuze, or *200 kt. W-80 nuclear device*
Date Deployed:	1983
Costs	\$500,000 - current production Unit Cost \$1,400,000 - average unit cost (TY\$) \$11,210,000,000 - total program cost (TY\$)
Total Program	4 170 missiles

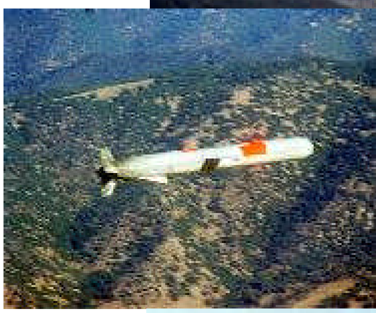
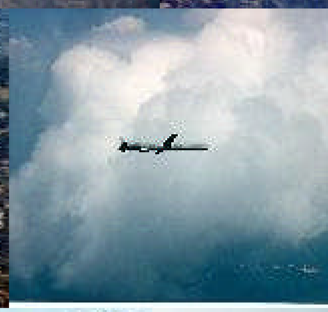

TOMAHAWK CRUISE MISSILE
BGM-109A
LAND ATTACK NUCLEAR
SIGNIFICANT FEATURES
CONFIGURATION OVERVIEW


IMAGING INFRARED SEEKER
TURBOJET ENGINE


Missile Features


Block III Improvements





ROYAL NAVY

GENERAL DYNAMICS/MCDONNELL DOUGLAS
BGM-109G "GRYPHON"
GROUND LAUNCHED CRUISE MISSILE (GLCM)
SPECIFICATIONS
PERFORMANCE

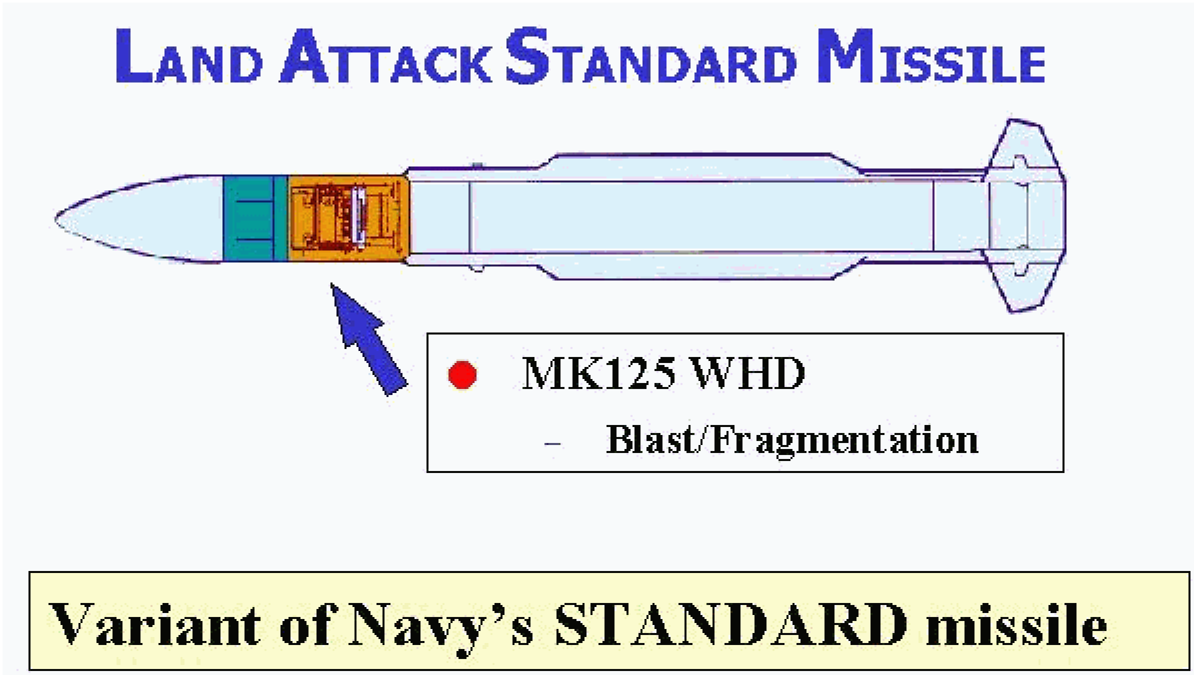

Land Attack Standard Missile [LASM]

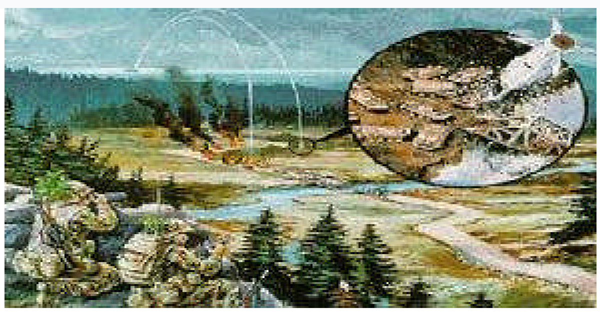
The CNO decided in late 1998 to modify the Standard missile for a surface-to-ground strike role. Studies determined LASM as the most cost-effective way to provide a rapid response, and all weather strike capability in support of military power projection ashore. The LASM mission will provide the required range, lethality, responsiveness and accuracy needed to support Marine Corps Fire Support requirements for Operational Maneuver from the Sea. This version of the Standard Surface-to-air missile is be reconfirmed for use against targets ashore at ranges up to 200 miles. The land-attack Standard missile (LASM), fitted with an advanced warhead and guided by GPS and its own inertial navigation system, will put at risk targets up over 150 nm inland.

The LASM builds on the successful thirty-year evolution of the STANDARD Missile, the US Navy's premier AAW weapon currently deployed on 50 destroyers and cruiser as well as with 13 Navies around the world. The LASM design maximizes use of common components, software and Non-developmental Items (NDI) between STANDARD Missile 2 (SM-2) Blk II/III and SM-3 LEAP (Lightweight Ex-Atmospheric Projectiles) minimizing development and production costs.

On 03 September 1998 the US Navy successfully conducted the third in the series of Land Attack Standard Missile (LASM) Concept Demonstration flights at the White Sands Missile Range, New Mexico. The objective of this particular test was to build upon a 24 July 1998 static firing of the Mk125 Warhead conducted at the Naval Surface Warfare Center, Dahlgren Division, Virginia in order to validate the warhead fragment pattern under actual missile flight conditions. The Mk125 warhead is currently deployed in STANDARD Missile-2 Block IIIA, IIIB, IV and the future IVA missiles possessing a proven reputation for devastating lethality and rugged reliability. The test used a modified STANDARD Missile-2 Block IIIA, carrying a modified Mk125 warhead which was optimized to the LASM’s terminal trajectory made to enhance effectiveness in the land attack role. The Mk125 modifications primarily involve alterations to the warhead’s explosive initiation system. The STANDARD Missile was launched from the Mk41 Vertical Launching System (VLS) and flew over 50 nautical miles on a pre-programmed flight path to a specific warhead burst point in an arena equipped with witness plates and optical equipment to verify warhead performance under dynamic conditions. This test combined with prior tests in the fall of 1997 and the spring of 1998 met all planned Concept Demonstration program objectives.

There are approximately 1200 rounds in the U.S. Navy's inventory available for LASM retrofit. Flight demonstrations are planned for FY1998 and FY1999 with an Initial Operating Capability (IOC) about 2003.


LAND ATTACK STANDARD MISSILE
MK125 WHD
– Blast/Fragmentation
Variant of Navy's STANDARD missile



RUR-5 ASROC
RUM-139 Vertical Launch ASROC (VLA)

The RUR-5 Anti-Submarine Rocket (ASROC) is a ballistic missile designed to deliver the Mk 46 Mod 5 torpedo to a water entry point. Navy surface ships employed the ASROC with two different payloads -- either a nuclear depth charge that used a W-44 nuclear device or the Mk-44 or Mk-46 lightweight acoustic torpedo. The ASROC weapons were relatively small devices designed to fit inside the distinctive eight-cell box launcher found on almost all cruisers and destroyers of that era. The rockets were about fifteen feet long, approximately thirteen inches in diameter, and weighed about a ton. The torpedo is a very sophisticated weapon, employing for its time, state of the art technology for the propulsion and guidance systems. The torpedo is about eight feet long, weighs about 600 pounds and is also carried in tubes on escort ships. After water entry, the torpedo powered up and chased the sub using either passive or active sonar.

The nuclear depth charge configured ASROC on the other hand was a relatively simple device, as it was nothing more complicated than a ballistic, unguided rocket with a depth charge as payload. When employing either weapon, the idea was to place the weapon as close to the predicted position of the enemy sub and let the weapon work as designed. In the case of the depth charge, after water entry, it simply sank and detonated at a preset depth. The resulting shock wave did the rest -- water doesn't compress, but sub hulls do.

The RUM-139 Vertical Launch ASROC (VLA) is intended to provide vertical launch-capable surface combatants (without ASROC rail launchers) with an all-weather, quick reaction, standoff antisubmarine weapon capability. It is installed in Aegis ships (cruisers and destroyers) with the Mk41 Vertical Launching System (VLS) and DD 963-class destroyers with Mk 41 VLS. VLA includes a solid propellant booster with thrust vector control (TVC) to guide the missile from a vertical orientation through a pitchover maneuver into a trajectory intended to deliver the torpedo to an aim point on the ocean surface.

Pre-launch commands for the VLA are provided by the ASW Combat System (ASWCS) which includes the Mk 116 Mod 6 (or 7) Underwater Fire Control System (UFCS), the Naval Tactical Data System (NTDS) data link receive capability, hull-mounted sonar AN/SQS-53B (the primary acoustic sensor for VLA targeting), towed tactical array sonar AN/SQR-19, data processor AN/SQQ-28 for sonobuoy data transmitted from a Light Airborne Multi-Purpose System (LAMPS) Mk III helicopter, and the operators. The

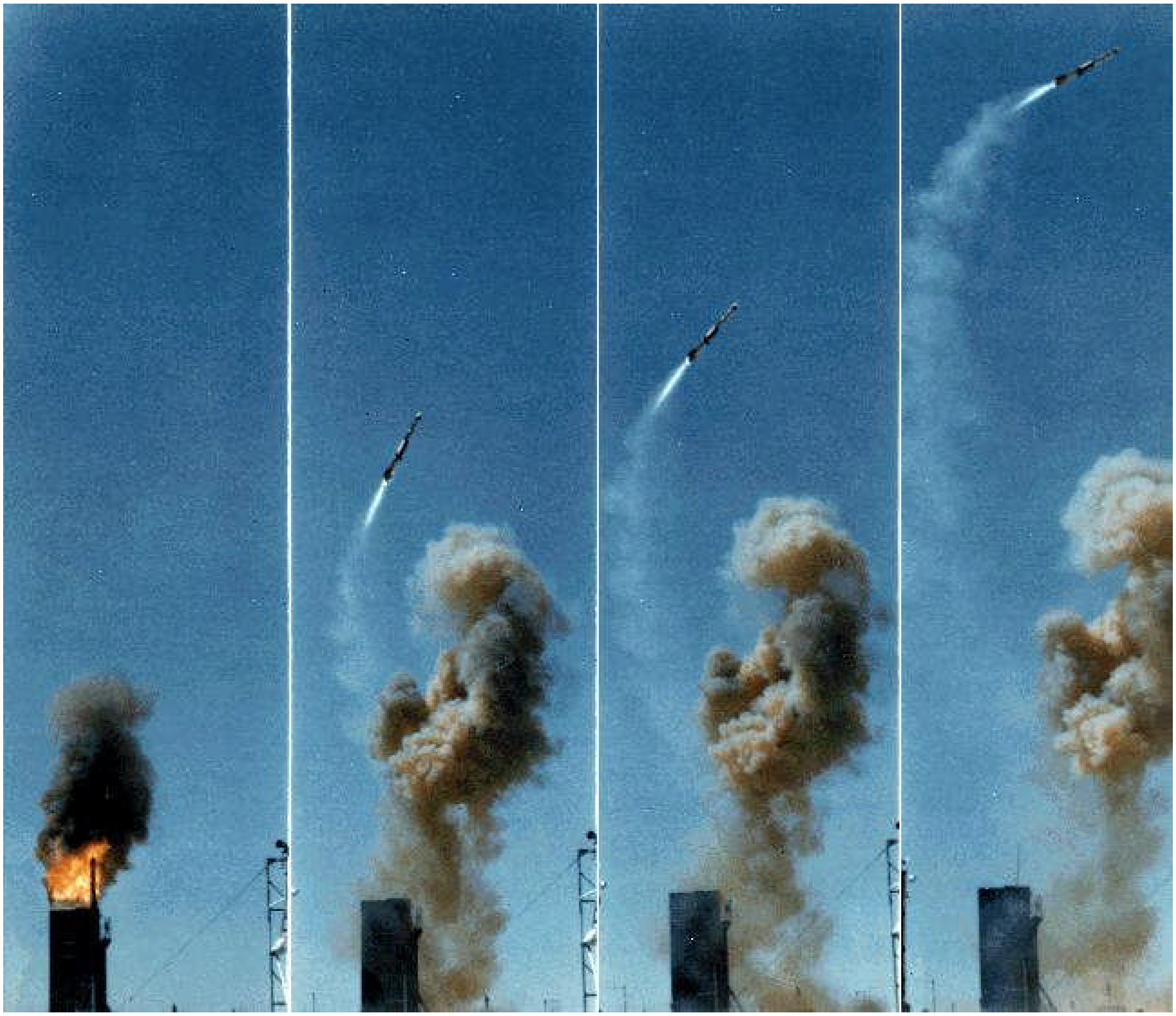
AN/SQS-53B and AN/SQR-19 are shipboard sensors which provide detection, classification, and localization (position and movement of target) information for processing by the UFCS. NTDS allows another platform (ship or aircraft) to share information that it has on enemy submarine position and movement with a VLA ship by transmitting the information for use by the UFCS. LAMPS Mk III can relay similar submarine information from its deployed sonobuoys to its assigned VLA ship. Localization information, in conjunction with environmental data at the launch ship (surface winds, relative humidity, for example), is used by the UFCS to compute an aim point (intended water entry point) for the VLA.
VLA missile inspection, as well as component replacement, missile assembly, and checkout (test) are conducted at an Intermediate Maintenance Activity (IMA) where the VLA missile is placed into a canister for storage or transportation to the ship. The canister is loaded into the VLS aboard ship and the VLA is fired from the canister. No corrective maintenance of VLA will be performed aboard ship. Component repair will be conducted at the depot level.
The VLA program was initiated in the early 1980s to fulfill the need for a mid-range attack capability for surface ships with vertical launch systems. The VLA program was canceled in April 1988, in anticipation that another acquisition program, Sea Lance, would result in a longer-range ASW standoff weapon. In late 1988 Congress provided funding for a one-time buy of 300 VLAs until the surface ship-launched Sea Lance was fielded. This quantity was subsequently defined as 100 missiles for LRIP, with an additional 200 missiles for full production. VLA development continued, with OPEVAL occurring in August 1990. COMOPTEVFOR concluded that VLA was not operationally suitable and that low reliability precluded evaluation of operational effectiveness. FOT&E was conducted during June through August 1992 (missile assembly and encanisterization at the intermediate maintenance activity at the Naval Weapon Station, Yorktown, VA during June-July, and at-sea operational testing at an underwater test range of the Pacific Missile Range Facility, Barking Sands, HI during late August).

The ship-fired, ASROC-delivered Mark 45 nuclear torpedo was parachute deployed before entering the water and searching for and finding the submarine target. The torpedo, moving at 40 knots until reaching the proper depth in the water, then began a horizontal movement toward the target. Once in place, the warhead detonated. SWORDFISH was a low-yield nuclear weapon test (less than 20 kilotons) of an antisubmarine rocket (ASROC) delivery system conducted in the Pacific. The underwater test produced a spectacular eruption on the ocean surface. Operation Sailor Hat involved using numerous conventional explosives to simulate nuclear blasts. Delta, the last Sailor Hat test in the ship evaluation program, was conducted to study seismological data, underwater acoustics, radio communications, cratering, air blast effects, cloud growth, fire ball generation, and electromagnetic data.

CHARACTERISTICS

Length: 192 inches
Diameter: 14.1 inches (body)
Weight: 1408 pounds

Power Plant: Solid Propellant Rocket
Warhead: MK 46 MOD 5 Torpedo
Guidance: Terminal Acoustic Homing with MK 46 Torpedo
Program: 438 missiles
Total program cost (TY$) $630.2M
Average unit cost (TY$) $0.84M
Full-rate production FY93
Prime Contractor
Loral Cleveland, OH



XMGM-52B Sea Lance

The submarine launched anti-submarine standoff weapon, Sea Lance, was intended to replace SUBROC, although it was cancelled while in full scale engineering development phase. Sea Lance was to carry the newly developed Mark 50 Advanced Light Weight Torpedo (ALWT) payload and the development program included an option for follow-on, nuclear bomb payload variant. Sea Lance incorporated a digital guidance system similar to the inertial guidance system used in ADCAP.

Sea Lance was capable of deep launch from a submarine torpedo tube with one of the two warhead options. The missile then is buoyed to the surface in a water-tight container where the solid propellent rocket motor ignites and delivers the weapon the target area at supersonic speed. At a point above the suspected target area, the warhead detaches form the rocket and parachutes to the water. Upon contact with water, the torpedo warhead assumes its search and attack pattern.

The deployment of Sea Lance was intended to complement the capabilities of the ADCAP torpedo by providing a stand-off option whereby an enemy submarine can be incapacitated from a distance well beyond the maximum engagement range of the ADCAP torpedo. In addition, Sea Lance was to provide expanded engagement opportunities against high speed transiting and evading submarines.

UUM-44 Submarine Rocket (SUBROC)

The UUM-44A Submarine Rocket [SUBROC] was a large weapon designed to be fired from a standard 21" submarine torpedo tube. The SUBROC is about the length and diameter of a standard torpedo, so that it could be ejected from a submarine tube. Once ejected from a nuclear submarine’s torpedo tube, the weapon clears the ship and then the solid fuel rocket motor ignites coming out of the water. After breaking the surface the booster accelerates to a predetermined altitude and speed before separating from the payload and tumbling back into the sea, flying up to 25-30 miles to the computed impact point. At impact with the sea, it performed some underwater terminal maneuvers to close the predicted position of the intended target. Finally finding its target, a 39-inch long Mark 55 thermonuclear warhead, weighing approximately 460 pounds, was then detonated. A direct hit is not necessary.

Nuclear warheads to be disassembled through mid-1999 include the W55 for the SUBROC.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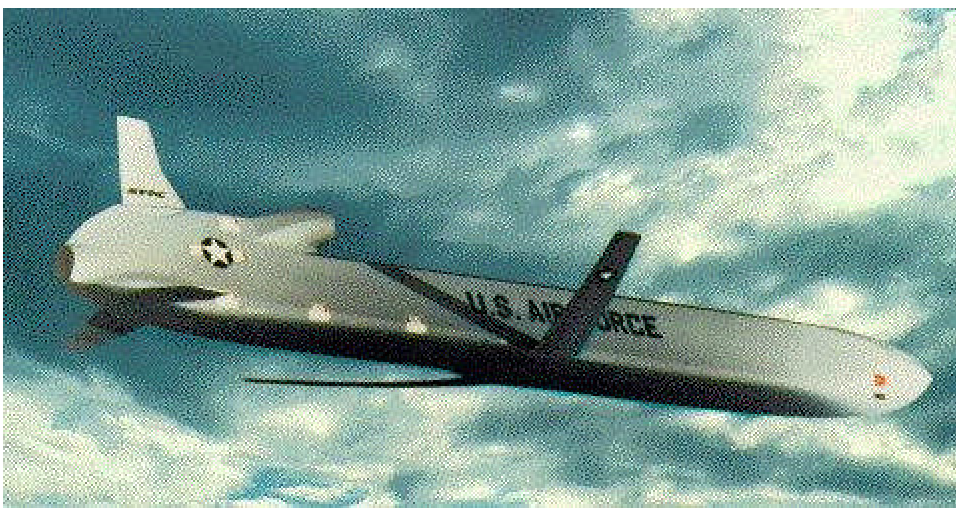
AGM-86C/D Conventional Air Launched Cruise Missile

The AGM-86C Conventional Air Launched Cruise Missile (CALCM) was developed to increase the effectiveness of B-52H bombers, dilute an enemy's forces, and complicate the defense of enemy territory.

The small, winged AGM-86C CALCM is powered by a turbofan jet engine that propels it at sustained subsonic speeds. After launch, the missile's folded wings, tail surfaces and engine inlet deploy. It then is able to fly complicated routes to a target through the use of an onboard Global Positioning System (GPS) coupled with its Inertial Navigation System (INS). This allows the missile to guide itself to the target with pinpoint accuracy.



The AGM-86C CALCM increases the Air Force's flexibility in target selection. The B-52H is capable of carrying six CALCMs on each of two externally mounted pylons and eight internally on a rotary launcher, giving the B-52H a maximum capacity of 20 CALCMs per aircraft. The AGM-86C CALCM differs from the AGM-86B Air Launched Cruise Missile (ALCM) in that it carries a conventional blast/frag payload rather than a nuclear payload and employs a GPS aided INS.

An enemy force would have to counterattack each of the missiles, making defense against them costly and complicated. The enemy's defenses are further hampered by the missile's small size and low-altitude flight capability, which also makes them difficult to detect on radar.

In February 1974, the Air Force entered into contract to develop and flight-test the prototype AGM-86A ALCM, which was slightly smaller than the later B and C models. The 86A model did not go into production. Instead, in January 1977, the Air Force began

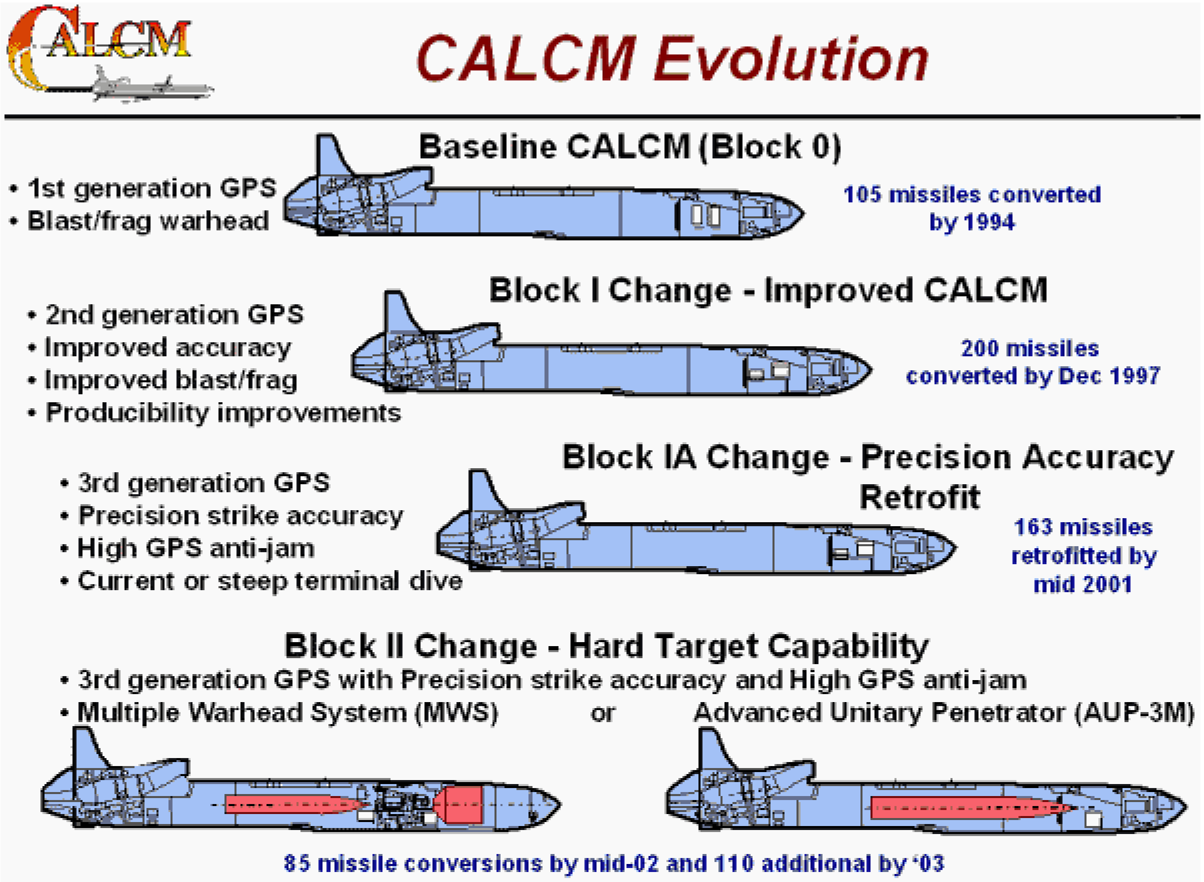
full-scale development of the AGM-86B ALCM, which greatly enhanced the B-52's capabilities and helped America maintain a strategic deterrent.

Production of the initial 225 AGM-86B ALCMs began in fiscal year 1980 and production of a total 1,715 missiles was completed in October 1986. The ALCM became operational four years earlier, in December 1982, with the 416th Bombardment Wing at Griffiss Air Force Base, NY, which deactivated when the base closed in 1995.

In June 1986, a limited number of AGM-86B ALCMs were converted to carry a high-explosive blast/fragmentation warhead and an internal GPS. They were redesignated as the AGM-86C CALCM. This modification replaced the AGM-86B ALCM's terrain contour-matching guidance system and integrated a GPS with the existing INS. This ALCM to CALCM modification program was conducted under under classified contract F34601-91-C-1156, which delivered the last lot of AGM-86C's to the Air Force in June 1993.

The CALCM became operational in January 1991 at the onset of Operation DESERT STORM. Seven B-52Hs carrying a total of 39 CALCMs flew nonstop round-trip from Barksdale AFB, LA to designated launch points in the U.S. Central Command's area of responsibility. At these points, 35 missiles were launched to attack high-priority targets in Iraq. These missions marked the beginning of the air campaign for Kuwait's liberation and are the longest known aircraft combat sorties in history (more than 14,000 miles and 35 hours of flight).

CALCM was subsequently employmd on 3 September 1996 in Operation DESERT STRIKE. In response to Iraq's continued hostilities against the Kurds in northern Iraq, the Air Force launched 13 CALCMs in a joint attack with the Navy. This mission put the CALCM program in the spotlight and helped propel the research and development of a multiple warhead penetrator version of the CALCM called the AGM-86D (Block II). CALCM was most recent employment occurred in December 1998 in Operation DESERT FOX. A total of $52 million was requested in the FY2000 budget to pay to replace the 90 conventional air-launched cruise missiles, plus two test missiles, fired against Iraqi forces during Desert Fox.



The CALCM **Block I** missile, currently in production, incorporates a 3,000-pound Class blast fragmentation warhead and Global Positioning System (GPS) receiver for navigation. The Block I system, when launched from CONUS based B-52 aircraft is highly effective against soft, above ground targets like Surface-to-Air Missiles (SAM) or radar sites. The new missile is twice as accurate, has twice the explosive capacity and costs two-thirds less than the Block 0 version. In 1995 Boeing was contracted to produce 100 Block I missiles. The CALCM contract order was increased to 200 units in 1996. In July 1996 Boeing delivered to the Air Force the first Block I CALCM with producibility enhancements for a conversion cost of approximately $150,000 per missile. . On 21 April 1999 Boeing was awarded a $41,310,000 firm-fixed-price contract to provide for the conversion of 95 excess AGM -86B Air Launched Cruise Missiles to Block I AGM-86C Conventional Air Launched Cruise Missiles.

Block 0/I missiles are being retrofitted to **Block IA** with a precision accuracy kit that uses a third generation GPS receiver along with advanced navigation software, and a GPS anti-jam electronics module and antenna for a significant increase in jamming immunity. The contract for Block IA was awarded in April 1998 with initial kit deliveries scheduled for July 2000. Under the development and production contract, Boeing will develop and deliver 28 missile retrofit kits to the Air Force, which will complete the missile kit installation. Major kit components include the GPS Receiver Interface Unit/Precision (GRIU/P) built by Interstate Electronics Corporation; a GPS anti-jam module built by Harris; and a four element GPS antenna array based on the design by Boeing Phantom Works. To increase CALCM effectiveness against a wider spectrum of targets, a

capability for shallow to near-vertical dive angles from any approach reference point also is being integrated. Flight software improvements include a large-state Kalman filter for optimizing GPS accuracy, to include code and phase measurement data, pressure and temperature measurements, and wide-area GPS enhancement to reduce system errors.

The AGM-86D **Block II** program is the Precision Strike variant of CALCM. It incorporates a penetrating warhead, updated state of the art, near-precision, GPS guidance, and a modified terminal area flight profile to maximize the effectiveness of the warhead. The penetrating warhead is augmented with two forward shape charges. To maximize the warheads effectiveness against hardened targets, the Block II will maneuver and dive onto its target in a near vertical orientation. The updated guidance system will increase the systems lethality by obtaining a less than 5 meter CEP. The Precision Strike variant of CALCM was successfully demonstrated in December 1996. A CALCM modified with a new precision GPS implementation flew for 4.5 hours, performed a newly developed steep terminal dive, and impacted the target within 2.5 meters of the aim point. The demonstration clearly showed that CALCM is capable of delivering it's warhead with precision accuracy from extremely long standoff ranges.
A feasibility study was concluded in April 1997, in which it was determined the BROACH Warhead on CALCM would offer very significant hard target capabilities. Foreign Comparative Test (FCT) funds have been provided by DoD for a demonstration of the UK's BROACH Warhead. The FCT concluded in late 1998. In October 1997 British Aerospace announced that Aerojet had been selected as its US partner in TEAM BROACH for product engineering and integration of the BROACH warhead system into US weapons.The BROACH multi-warhead system, also under evaluation for the the Joint Stand-off Weapon (JSOW), achieves its results by combining an initial penetrator charge (warhead) with a secondary follow-through bomb, supported by multi-event hard target fuzing. The outcome is a warhead and fuze combination that provides for the defeat of hardened targets more than twice that achievable for equivalent single penetrating warhead types, at an equivalent weight and velocity. The warhead technology can be scaled and configured for a variety of weapon payload and targets requirements The current Block II program is structured for EMD to begin in first quarter FY99 with missile production to commence in third quarter FY00. Total procurement is for between 130 and 195 missiles.

In the 4-day Operation Desert Fox attack on Iraq in December 1998, the United States used 90 conventional air-launched cruise missiles. When NATO bombing of Serbia began, the military fired between 30 and 50 air-launched cruise missiles targeted primarily against Serbian air defenses. By mid-April 1999 there were 90 to 100 conventional air-launched cruise missiles in inventory. On 21 April 1999 Boeing was awarded a $41,310,000 firm-fixed-price contract to provide for the conversion of 95 excess AGM -86B Air Launched Cruise Missiles to Block I AGM-86C Conventional Air Launched Cruise Missiles. Expected contract completion date was 30 November 1999. If the production line for new air-launched cruise missiles was reopened at Boeing, it would take several million dollars of commitment and funding simply to restart it. Even if that happened, the line would not even begin producing new missiles for more than a year.

Specifications

Primary Function:	Air-to-ground strategic cruise missile			
Contractor:	Boeing Defense & Space Group Aerojet - CALCM warhead			
Guidance Contractors:	Litton Guidance & Control, Rockwell Collins Avionics, and Interstate Electronics Corp.			
Power Plant:	Williams International Corp. F-107-WR-101 turbofan engine			
Thrust:	600 pounds			
Length:	20 feet, 9 inches			
Weight:	3,250 pounds			
Diameter:	24.5 inches			
Wingspan:	12 feet			
Range:	Nominal: 600nm Specific: Classified			
Speed:	Nominal: High Subsonic Specific: Classified			
Guidance System:	Litton Inertial Navigation Element integrated with an onboard Global Positioning System			
VARIANTS	AGM-86C Block 0	AGM-86C Block I	AGM-86C Block IA	AGM-86D Block II
Warhead:	1,500-lb AFX-760 Blast Fragmentation Warhead	3,000-lb PBXN-111 Blast Fragmentation Warhead		Penetrating Warhead
Initial Operational Capability:	Jun 1986	Jul 1996	Jul 2000	mid-2002
Full Operational Capability:	Jun 1993	Nov 1999	2001	2003
Total Production:	105	295	163	130 - 195
Deliveries [as of 15 Apr 99]	105	200	0	0
Combat Expenditure:	39 + 13 + 50	40 + 60		
Current Inventory:	? 0	~100	0	0
Unit Cost:	$ 150,000 conversion cost $ 600,000 contract price per unit			

$1,500,000 [$FY90, based on GAO Desert Storm estimate]
$1,875,000 [$FY99, based on GAO Desert Storm estimate]

Low Cost Autonomous Attack System (LOCAAS)
Miniature Munition Capability

As of 07 January 1998 ACC approved a new acquisition strategy for the Small Bomb System (SBS) program. This strategy involves integrating the SBS on the F-22, F-22X and JSF and also includes combining the SBS and the Low Cost Autonomous Attack System (LOCAAS) efforts into a single program. This new program has been designated Miniature Munition Capability and has a planned start date for FY03. Implementation details of the new strategy are still being developed.

The LOCAAS is envisioned as a miniature, autonomous powered munition capable of broad area search, identification, and destruction of a range of mobile ground targets. LOCAAS is a low-cost LADAR sensor coupled with a multimode warhead and a maneuvering airframe to produce a high performance submunition. The warhead can be detonated as a long rod penetrator, an aerostable slug, or as fragments based on the hardness of the target. The LADAR allows target aimpoint and warhead selection to be determined automatically. The powered LOCAAS uses small turbojet engine which is capable of powering the vehicle for up to 30 minutes. Powered LOCAAS has a 33 sq. nm search area. On 17 December 1998 the Air Force Research Laboratory, Eglin AFB awarded Lockheed Martin of Dallas TX a $32,942,000 Other-Transaction-for-Prototype contract to provide for the Powered Low Cost Autonomous Attack Submunition (P-LOCAAS) advanced technology demonstration.This program includes system design, concept definition, fabrication and test of a LOCAAS prototype. An Other Transaction is a special acquisition method to develop prototype projects for which most procurement laws and the Federal Acquisition Regulation do not apply, thus allowing greater flexibility in meeting government requirements. Expected contract completion date is 10 December 2001.

The Munition Directorate Assessment and Demonstrations Division of the Air Force Research Laboratory (AFRL) planned to pursue a procurement of an Advanced Technology Demonstration (ATD) program for the Powered Low Cost Autonomous Attack System (LOCAAS). The anticipated contract value of this effort is $12-14M between FY99-02. The purpose of the ATD is to demonstrate that a low cost, [NTE $30K average unit production cost (AUPC), not including the cost of dispensers/dispensing mechanisms], system can be produced using a Multi-Mode Warhead, solid state Laser Radar (LADAR) seeker with Autonomous Target Recognition (ATR), and INS/GPS midcourse guidance and that these components can be integrated into an air vehicle powered by a miniature turbojet engine.

The overall objective of the ATD is to provide an affordable standoff (minimum 90 miles) miniature munition to autonomously search for, detect, identify, attack, and destroy theater missile defense, surface-to-air missile (SAM) systems (i.e. SEAD) and

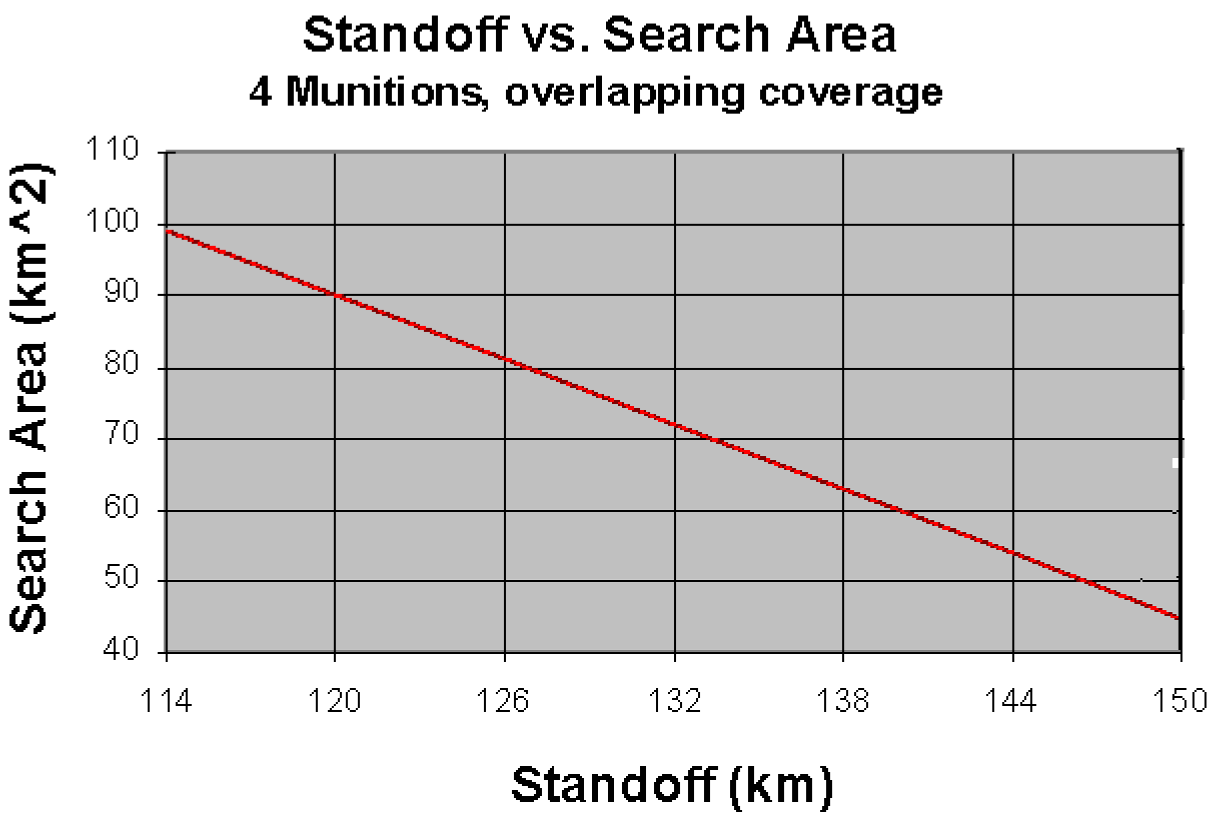
interdiction/armor targets of military interest. The system will be capable of discriminating between classes/types of targets and between targets and non-combatants. The Powered LOCAAS system will be designed so as to be produced for less than $30,000 AUPC based on production of 12,000 units in 1994 base year dollars.

The basic strategy contemplated for the ATD is a four phased program.
Phase I may consist of no more than two fully qualified contractors competing for downselect. This is a 6-12 month effort consisting of three main tasks. (1) Concept Definition: Which consists of a complete requirements flow down for entire munition system and address all munition performance requirements as well as mission planning dispense/delivery concepts. (2) System Design: A Detailed design for the entire munition, to include tactical safe/arm device (or function) and warhead interface. Munition design must be compatible with TMD (SUU-64, 66, 4 LOCAAS/TMD) dispense and be form/fit compatible with ATACMS and MLRS. In order to verify a dispensable design, sufficient level details must be provided for the TMD dispense system. (3) Preliminary Seeker Captive Test: Operate a tactical seeker testbed in accordance with the concept definition and system design. All proposed scan modes and decision logic must be implemented in both hardware and software (including ATR). The ability to autonomously identify targets in all three target groups (Attack Ops, SEAD, Armor/Interdiction) must be demonstrated. The ATR must be demonstrated in real time operation using a representative flight processor.

Phase II is a 2-year effort that will consist of three major tasks. (1) Tactical Seeker Fabrication & Qualification: Fabricate a form factored seeker for captive flight test. Seeker optics and gimbals should be essentially identical to those fabricated for flight test, with the exception of any modifications necessary to ensure extended use under captive flight test. (2) KHILS Seeker Fab & Installation Support: Fabricate tactical seeker (for delivery to AFRL’s KHILS facility) will include mass balance gimbals/gimbal control system, PCE board, and flight processor (optical elements will consist of mass balance mockups). (3) Tactical Seeker captive Test: Test will demonstrate performance of seeker under full range of tactical scenarios. A minimum of three, 4-week test sequences in different geographical locations will be conducted, covering the full spectrum of LOCAAS targets and background settings. Performance vs. Known (deployed or soon to be deployed) countermeasure will be evaluated. Specific exit criteria will be established for selected missions and the LADAR/ATR performance will be judged against these criteria.

Phase III is a 2-year 6-month effort to be run in parallel with Phase II. This phase will consist of 2 major tasks. (1) Tactical Munition Fabrication: Fabricate flight test articles to support a control flight test and three powered, guided flight tests with inert warheads. Sufficient number of warheads shall be fabricated to demonstrate tactical level performance, including end-to-end fire train. (2) Tactical Munition Qualification: Qualification test for entire range of test environments.

Phase IV is the culmination of Phases I - III and shall conduct up to four guided flight tests as discussed above.



Specifications

Length	30”
Wingspan	40”
Box size	8”x10”
Weight	90-100 lbs
Engine	30 - 50 lb thrust class turbojet
Endurance	30 min expected
Range	> 100 km
Guidance	INS/GPS midcourse guidance Solid State LADAR Seeker • Large Field of Regard • Autonomous Target Acquisition • Simplified Mission Planning
Warhead	Multi-mode Warhead • Stretching rod for hard armor penetration • Aerostable slug for increased stand off

- Fragments for soft target kill

Max aircraft loadout

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F-16    4 SUU-64 / 16 LOCAAS
F-15E   5 SUU-64 / 20 LOCAAS
F-22    2 LODIS /  16 LOCAAS
JSF     2 LODIS / 16 LOCAAS
B-52    16 SUU-64 / 64 LOCAAS
B-1     30 SUU-64 / 120 LOCAAS
B-2     16 LODIS / 192 LOCAAS
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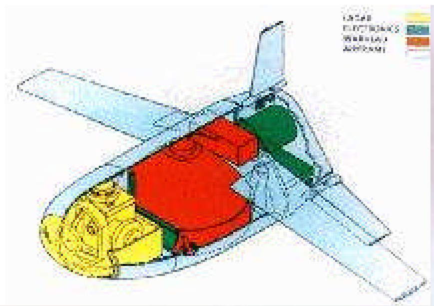
Cost goal

$33K Unit Production Cost
(FY98$, 12,000 unit buy)




Fast Reaction Standoff Weapon [FRSW]

The Fast Reaction Standoff Weapon [FRSW] is a hypersonic solid rocket powered boost/glide weapon with an average velocity of mach 8.1 in order to provide rapid response to time sensitive targets. Weapon can be launched from most fighters and bombers from standoff ranges outside theater defenses. Guidance is anti-jam GPS/INS. FRSW can carry two Small Smart Bombs (SSB) for buried/hard target attack such as storage facilities for weapons of mass destruction.

LOCAAS has a low-cost solid state LADAR sensor coupled with a multimode warhead and a maneuvering airframe to produce a high performance submunition . Guidance/sensor integrated fusing allows the warhead to be detonated as a long rod penetrator, an aerostable slug, or as fragments based on the hardness of the target. The high resolution LADAR allows target aimpoint and warhead selection to be determined automtoically. The powered LOCAAS uses a small turbojet engine which is capable of powering the vehicle for up to 30 minutes. LOCAAS will provide automatic target recognition and allow effectiveness against the full spectrum of mobile SEAD and TMD targets. Powered LOCAAS has a 33 sq. nm search area.

Affordable Rapid Response Missile Demonstrator (ARRMD)

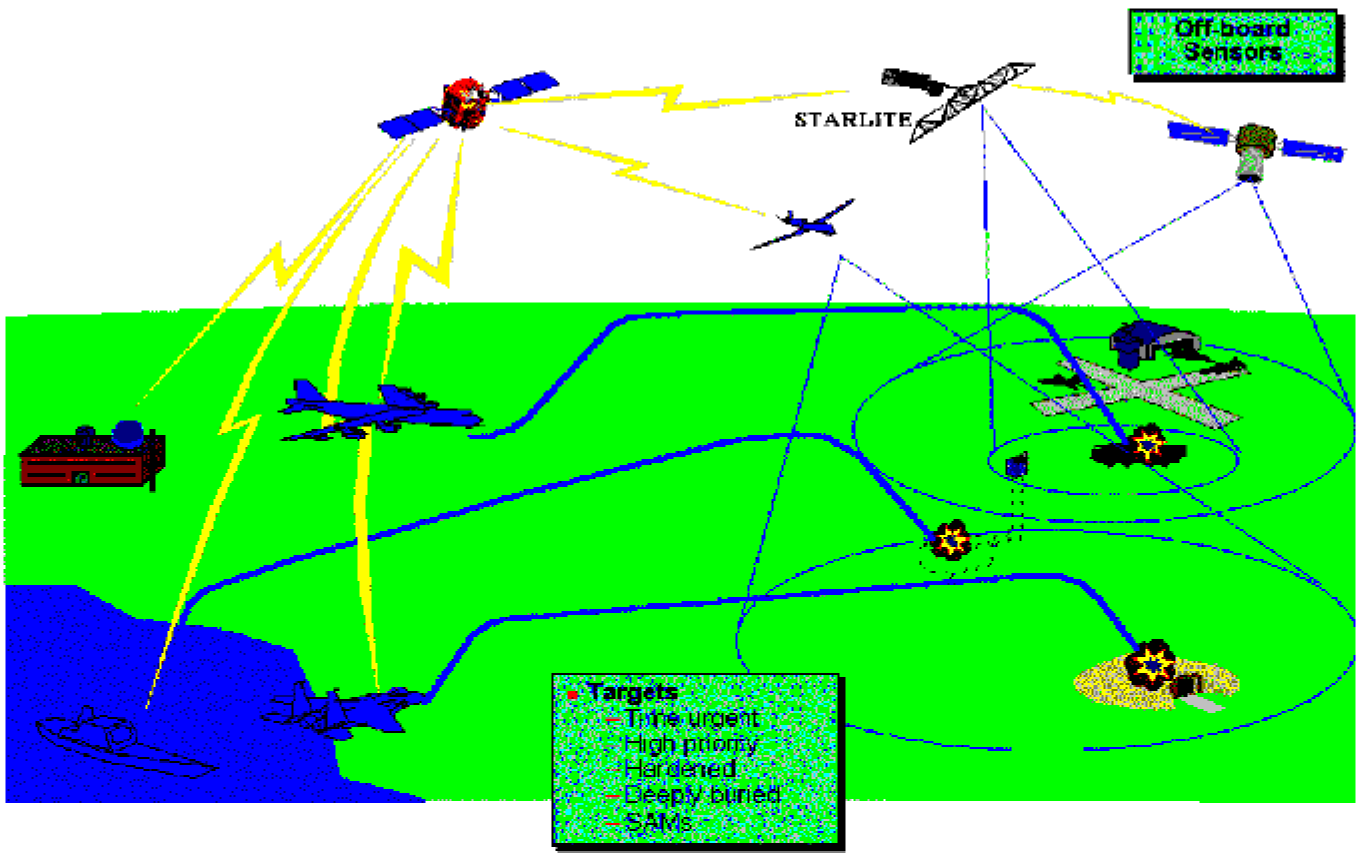
The objective of the DARPA Affordable Rapid Response Missile Demonstrator (ARRMD) program is to build and demonstrate in flight an affordable Mach 6-8, scramjet-powered, hydrocarbon-fueled missile for conduct of rapid-response, long-range missions against time-critical (2-8 min, 100-600 nmi) targets. In addition, a high-speed missile would enable nano-layer structured penetrators to take advantage of much higher impact velocities for the defeat of hard and deeply buried targets.
Specific program goals include: (1) demonstrate affordable manufacturing processes to enable hypersonic missile production at an average unit flyaway price of $200K; (2) develop a concept of operations with the user for a high-speed missile; (3) demonstrate aeropropulsion performance of a high-speed missile launch platform compatibility with tactical aircraft and the Navy's Vertical Launching System; and (4) achieve Mach 6-8 cruise with an overall range of 400 - 600 nmi.
The program has been designed as a two-phased program to enable risk reduction associated with demonstrating that hypersonic missile technologies can be delivered affordably. In the $10 million first phase, two contractors will design a high-speed flight vehicle, perform manufacturability demonstrations, conduct propulsion integrated flow path demonstrations, and perform flight test planning. In addition, an independent affordability assessment and warfighting payoff assessment will be performed. The affordability assessment will provide insight and confidence in the ability of industry to achieve a $200,000 average unit flyaway production price. The warfighting payoff assessment will lay the groundwork for establishing military utility of a hypersonic missile.

In August 1998 the Boeing Phantom Works was awarded a $10 million 18-month contract to design and conduct developmental tests of two different hypersonic vehicle concepts, each capable of cruise speeds of more than Mach 6. One vehicle has a long, wide, flat shape, which will allow it to ride on its own shock wave for reduced drag. This "waverider" concept will be propelled by a supersonic ramjet (scramjet) engine currently being developed by Pratt & Whitney for the U.S. Air Force. The other vehicle has a more traditional cylindrical shape. It will use a dual-combustion ram/scramjet engine originally developed by Johns Hopkins University Applied Physics Laboratory for the US Navy but now being adapted for ARRMD by Aerojet.

The $50 million Phase 2 may follow successful completion of Phase 1, through a contract option to assemble flight vehicle(s) and conduct flight demonstration testing. If ARRMD performance and affordability objectives can be demonstrated under the first phase of the agreement, DARPA plans to continue with a 30-month producibility and flight test demonstration program with one or both of the hypersonic concepts. A hypersonic missile flight demonstration is planned in the program in 2001.

A successful ARRMD program would allow the Department of Defense to pursue an engineering and manufacturing development program as early as 2004 and have an operational missile in the US Navy and Air Force fleets by 2010.

The Air Force Hypersonic Technology (HyTech) Program has put programs in place to develop the technologies necessary to demonstrate the operability, performance and structural durability of an expendable, liquid hydrocarbon fueled scramjet system that operates from Mach 4 to 8. This program will culminate in a flight type engine test at representative flight conditions. The hypersonic technology base that will be developed and demonstrated under HyTech will establish the foundation to enable hypersonic propulsion systems for a broad range of air vehicle applications from missiles to space access vehicles. Pratt & Whitney is developing the technology for hypersonic components and engines. A supersonic combustion ramjet (scramjet) database was developed using hydrogen fueled propulsion systems for space access vehicles and serves as a point of departure for the current development of hydrocarbon scramjets.



HyStrike
High Speed Strike Missile
Fast Hawk
Low-Cost Missile

HyStrike will begin the development of an operational hypersonic weapon that will be fielded in the 2005 to 2012 time frame. A Low-Cost Missile with reduced radar cross-section is to be demonstrated by the US Navy. The surface-launched system could hit underground targets to a depth of 12 meters after flying at beyond Mach 4. The wingless missile would change direction in flight by using a bending body joint. The LCMS concept comprises a fin-less, bending body airframe, fixed geometry annular inlet, and a slip-out booster/ramjet engine. It demonstrates through a series of ground and flight tests the technologies required to deliver a 700-pound payload to a range exceeding 700 nautical miles at a speed of Mach 4.0.

The Office of Naval Research sponsors the Hypersonics Weapons Technology (HWT) and the Low-Cost Missile (LCM) programs. The HWT Program is investigating technologies necessary for effective weapon-system operation in the hypersonic realm. The LCM Program - commonly known as Fast Hawk - is developing an entry-level capability for a Mach 4 hypersonic weapon. Both of these ONR programs will feed into the Hypersonic Strike (HyStrike) Program sponsored by the chief of naval operations (N88; N87; and N86).

A unique aspect of this Navy programs is that the goal is a single hypersonic strike weapon that will be launchable from air, surface and subsurface platforms. This is a first-time collaboration between these three communities to develop a common weapon system for time-critical and deeply buried targets. It is intended to produce increased operations effectiveness as well as life-cycle cost saving.

When fielded, the hypersonic strike weapon is intended to have a major positive impact on battlespace management. The weapon's greatly decreased time to target will give the command, control, communications, computers and intelligence (C4I) components more time to search for and identify time-critical threats. Powerful kinetic penetrators will defeat the enemy's tactic of burrowing deeper or building stronger bunkers. And the ability to take out threat weapons before they are launched will increase US and allied survivability, efficiently, cost effectively - and soon.

The hypersonic weapon's immense destructive power results from kinetic energy. An object striking a target at Mach 8 will generate 64 times the force of an object of the same mass striking the target at Mach 1. This phenomenon makes hypersonic weapons well suited to attacking hardened or deeply buried targets such as command bunkers or biological-weapon storage facilities.

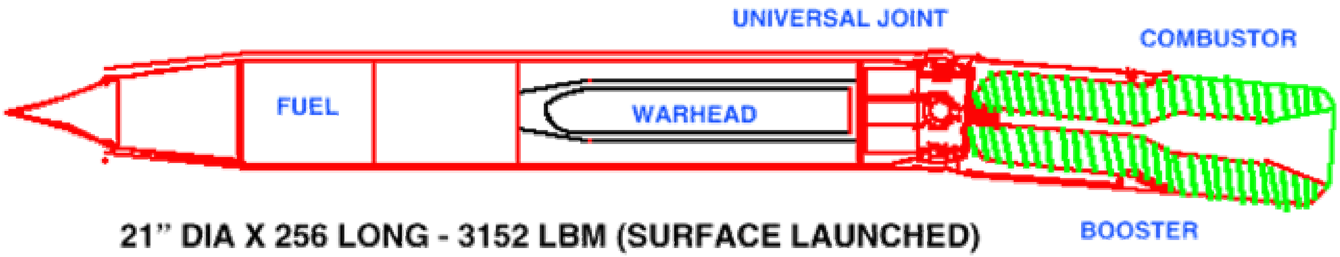
Aerothermic heating, caused by the friction of air passing the weapon body, is one area of intensive research. At Mach 4, as the hypersonic weapon passes through the lower atmosphere in the terminal phase of its flight, its surface reaches about 1200 degrees Fahrenheit. This level is within the tolerance range of new titanium and inconel materials. At Mach 6, however, the surface temperatures exceed 2800 F and at Mach 8 over 5600 F; skin materials, as well as internal temperature control, become a much larger issue.

On 25 March 1997 The Boeing Company received an $8 million contract from the US Navy for the Low Cost Missile System (LCMS) Advanced Technology Demonstration (ATD) program, called Fasthawk. The 36-month program will demonstrate technologies applicable to a next-generation, ship-launched, land attack missile system. The LCMS ATD program is conducted jointly with the Naval Air Warfare Center, China Lake, CA.

The compliance of this system with various bilateral arms control treaties remains an unresolved issue.

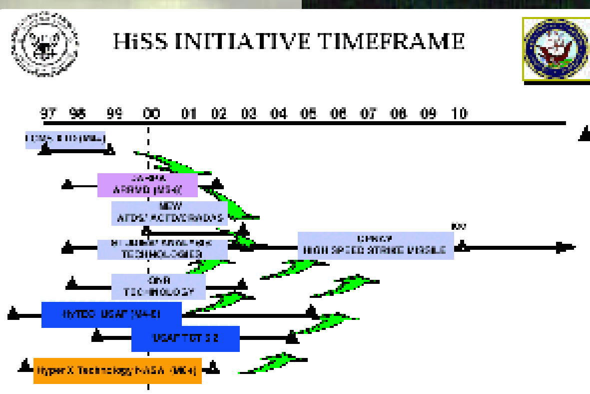
Specifications

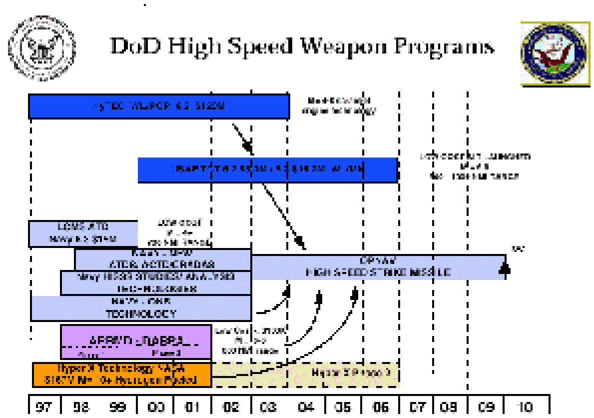
Mission	Attack, Destroy, & Hold at Risk Short Dwell and/or Time-Critical Targets at Long Standoff Ranges
Range	up to 600 nmi / over 700 nmi
Average speed	Mach 3.5 to Mach 7 2600 mph - 5200 mph
Features	• High weapon survivability • Penetration of 18-36 feet of concrete • Reactive SEAD • Day, night, adverse weather operation • Family of Hypersonic Cruise Missiles • Neckdown to 1 type of Weapon vice 6 currently • Minimize cost of ownership
Operational	2010 IOC
Platforms	Navy/Shipboard compatible F/A-18 E/F, JSF, F-22, F-16, F-15E, B52, B-2,B-1, MLRS, Surface ships, & submarines

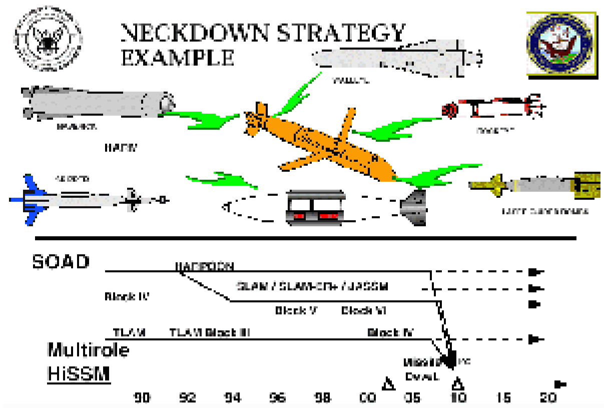


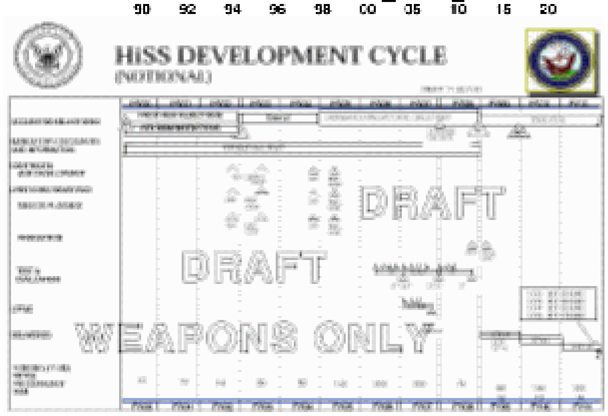
21" DIA X 256 LONG - 3152 LBM (SURFACE LAUNCHED)

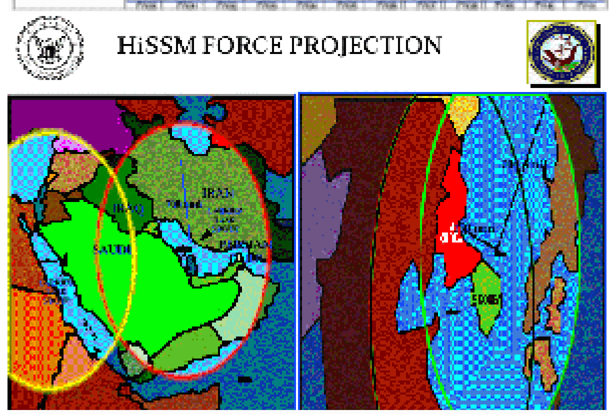
21" DIA X 168" LONG - 1980 LBM (AIR LAUNCHED)

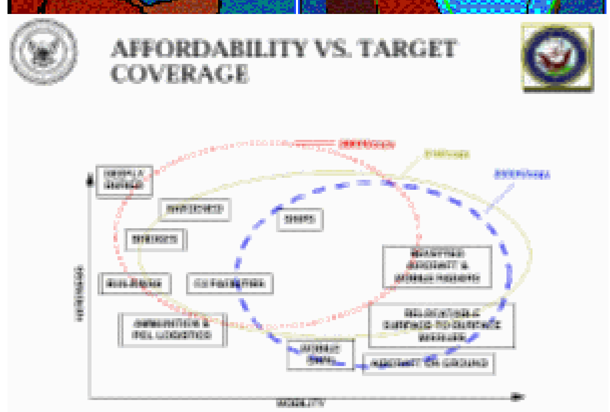





NECKDOWN STRATEGY
EXAMPLE
SOAD
HARPOON
SLAM / SLAM-ER / JASSM
Block IV
Block V
Block VI
TLAM
TLAM Block III
Block IV
Multirole
HiSSM
90 92 94 96 98 00 05 10 15 20


HiSS DEVELOPMENT CYCLE
(NOTIONAL)
DRAFT
DRAFT
WEAPONS ONLY


HiSSM FORCE PROJECTION
IRAN
IRAQ
SAUDI


AFFORDABILITY VS. TARGET
COVERAGE
SHIPS